Instruments

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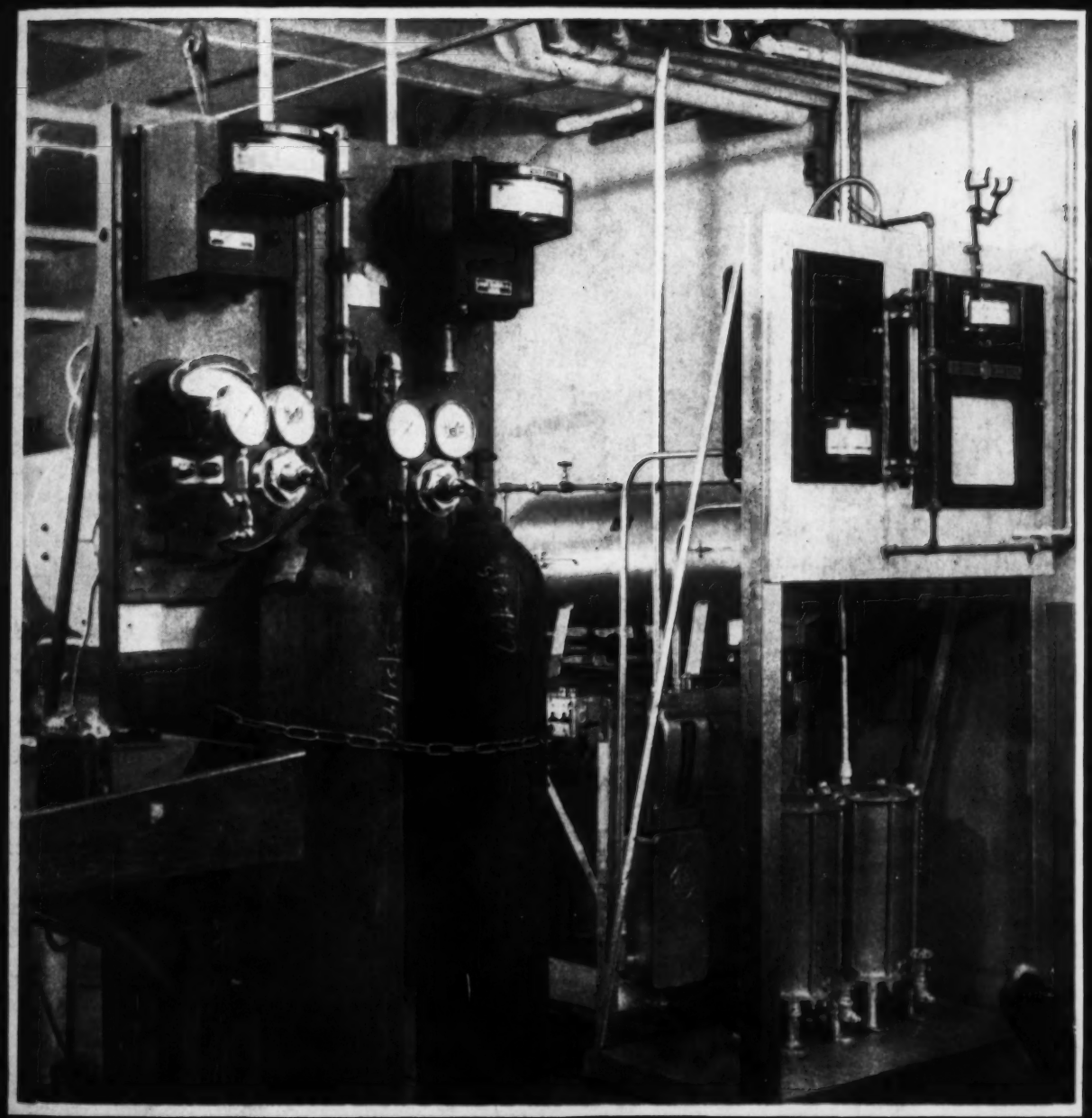
luding the *JOURNAL* of the Instrument Society of America



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Your Work's Growing Importance

EVERY few years this page reports "straws in the wind" indicating recognition of Instrumentation by more and more societies, industries and other bodies of men. It is a pleasure to report at this time that the wind continues to blow favorably. Judge for yourself:

I

The American Association for the Advancement of Science, founded in 1848, is conservative. Its periodicals—*Science* and *The Scientific Monthly*—resist every temptation to play up innovations. In 1942, one relatively small segment of the AAAS recognized Instrumentation by placing this subject on its summer schedule of Chemical Research Conferences,* but this victory was won by an energetic non-member** assisted by three members.† Now, without outside prompting, the AAAS has brought out an issue of *Science* (Vol. 110, No. 2858, Oct. 7, 1949) bearing on its cover the words *ANNUAL INSTRUMENTS ISSUE* and with the following contents:

Featured Articles: (1) "Is There a Science of Instrumentation?" by E. U. Condon; (2) "Operational Aspects of Instrument Design" by Churchill Eisenhart.

Reports of Meetings: (1) The Fourth Annual Conference and Exhibit of the Instrument Society of America; (2) Fourth Conference on Low Temperature Calorimetry; (3) Symposia on Conformal Mapping and the Monte Carlo Method; (4) International Conference on Instruments and Measurements.

Summaries of Selected Papers: (1) From the 1949 National Instrument Conference: [eight extended abstracts]. (2) From the 1949 Gordon Research Conferences: [four extended abstracts].

Technical Papers [six, all on scientific instruments].

Congratulations to *Science*, especially on obtaining an article by that busiest of all burdened scientists, that staunch friend of his fellow Instrument Men, Dr. Condon! By the way, although the title of his article is in the interrogative mood, he concludes indicatively: "These examples . . . reinforce the concept that instrumentation is a science in its own right."††

As we go to press we note that the other AAAS organ, *The Scientific Monthly*, in its November issue has an article by Professor John D. Trimmer, Physics Dept., U. of Tennessee, on "Instrumentation and Cybernetics." This title would not be acceptable to *Instruments* which holds that cybernetics (or kratology‡) is one branch of Instrumentation, but we shan't quibble with Dr. Trimmer (whose course in Instrumentation is scheduled to be described in an early issue of *Instruments*) because his article is more philosophical than technical and because he eloquently declares that

> Instrumentation has grown, and is still growing, into some kind of superinstrumentation. Or, expressed another way, instrumentation is the core around which a much larger structure of ideas is crystallizing and taking shape.

which "mode of thinking" (Trimmer's words) beautifully echoes the "mode of thinking" on "the Greater Instrumentation" disclosed in 1932 on pages viii, ix and x of the Preface to Fundamentals of Instrumentation.

II

To most of our subscribers, Dr. Philip W. Swain, Editor of *Power* since 1934 needs no introduction: they have heard him speak at sessions and luncheons and dinners of nearly every technical society; or have seen him visiting their own plants or labs. Somehow, he did not attend the first three National Instrument Conferences. When he attended the fourth—at St. Louis last September—he instantly became an Instrumentation enthusiast. Here is the conclusion of the editorial, titled "The Age of Instruments," which he wrote on his return:

> Like power itself, instrumentation is something fundamental and universal. When you see where it stands today you will draw many far-reaching conclusions. Here are some impressions from St. Louis:
>
> 1—Who said small business is on the run? Most of the instruments and controls shown at St. Louis, including some of the most ingenious and elaborate, are products of small firms—most of whom don't seem to worry very much about the competition of big business.
>
> 2—Instrumentation will continue its rapid growth, not merely because Americans take to gadgets, but more because hard-headed business management sees more automatic control as the road to solvency and profits in the face of high labor rates and keen competition.
>
> 3—For obvious reasons, the military and other government branches will encourage instrument progress and contribute greatly to it.
>
> 4—Yet most of the progress will trace right back to ingenious individuals in industry, supported by progressive business management.
>
> 5—As the years roll by, plant operation will call for less and less muscle, more and more instrument savvy. Even the smallest plants will come around to automatic control.
>
> 6—While instrument engineering has become highly specialized, the average power engineer will find long-known principles at work—orifice, venturi, pitot tube, diaphragm, metal bellows, bourdon tube, thermocouple, hot wire, liquid column—plus a few new ones, such as the magnetic property of oxygen.
>
> 7—Of course, the oldtimers will have to brush up on electronics.
>
> 8—Will all these automatic controls take the fun out of life for men who like to work with machines? Why should they? There will still be planning, installation, maintenance, repair of all equipment, plus the really high-class mechanical and electrical jobs of keeping instruments and controls in top-notch working condition.

III

And the October issue of *Electronics* contains, for the first time in its history, a feature on industrial instrumentation methods—not only electronic but pneumatic, hydraulic, mechanical, electromagnetic, etc. *Power*'s editor advises his readers to brush up on electronics; the editors of *Electronics* help their readers brush up on non-electronic instrumentation by presenting the ABC's in a clever combination of text, tables and thumb-nail sketches—all with remarkably few errors.

IV

Another straw, which we failed to stress in last month's editorial on the 1949 ISA Conference, is the record-breaking number of scientific and technical bodies which participated: no fewer than six!

V

E. G. Bailey, President of Bailey Meter Co., is being succeeded as ASME President by James Cunningham, President of Republic Flow Meters Co. Two instrument engineers in succession! *AND* a new ASME V-P will be Professor S. H. Graf, head of the M.E. Dep't at Oregon State College since 1934, who has been giving since 1940 an Instrumentation course officially named "Instrumentation."

VI

The "Technology" department of the November *Fortune* bears the title "A Key to the Automatic Factory" with the sub-title "The computers that direct guns might also direct machines"; with the Arma Corp. as case-study; with beautiful colored diagrams of analog computers, etc.; and —of course!—with *Fortune*'s peculiar combination of reportorial emphasis and editorial slanting.

VII

The favorable wind of recognition from top management of industries recently modernized (or created) by Instrumentation blew a little stronger a year ago, following the appearance of Chase National Bank V-P Frank Totton as the principal speaker at the ISA's Annual Dinner. This year it seems to blow stronger still, the straws being job retentions in the face of strike-created difficulties, job advancements in some cases, and even a few new high-salaried openings. (Too few, but this is not 1959!)

VIII

Recognition comes from labor-union officials. A few are for automatic control: they are the true leaders who work for the up-grading of their members and recognize that Automaticity Makes Jobs. Some pay lip-service to technological progress but do nothing. Some rant against innovations that increase individual productivity and, according to recent news items, work for laws forbidding or hampering the introduction of such methods. So here we have three straws, indicating a favorable wind, a calm, and an unfavorable wind. Which is the correct indication? Your guess is better than that of

M. F. BEHAR

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*See *Instruments*, March 1942, page 63; Sept. 1942, page 337; both on the AAAS.

**Richard Rimbach, publisher of *Instruments*, who has never received due credit—and who would suppress this mention if he knew about its last-minute insertion.

†(1) The late Dr. Neil Gordon, Founder and General Chairman of these conferences, which today are known as the Gordon Research Conferences; (2) Dr. John J. Grebe, Director of Physical Research of the Dow Chemical Co.; (3) the anonymous author "Verba Volant Scripta Manent," August 1942 *Instruments*, pages 298 et seq.

††"Instrumentation is a science in its own right—a science which is indebted to all other sciences but which in turn enriches them all." (From editorial on Instrumentation's Unity in June 1942 *Instruments*.)

‡From the Greek for "to exercise power." This name was given in 1932 to the new science of closed-loop control in both technology and human affairs. It had been suggested by Pittsburgh Univ. Greek Dep't. instructors we had previously consulted. And now—another straw?—those inspired scientific wordsmiths, Parry Moon and Domina Eberle Spencer, have suggested "kratos" as a universal technical term for "power."

Texas A&M's Fourth Annual Short Course

The fourth annual Short Course on "Instrumentation for the Processing Industries" was conducted on October 12, 13 and 14 by the Department of Chemical Engineering, Agricultural and Mechanical College of Texas. *Instruments* takes pleasure in giving a pictorial report. [illegible] attended; *upper right*: view of part of the exhibit hall; *lower right*: in the lecture hall; *lower left*: the instructors. *Front row*: J. M[illegible] McCullough, A. I. Dahl, G. A. Martin. *Back row*: D. H. Fuller, F. D. Spuhler, W. H. Fortney, H. K. Eckert. *Not pic-*

Organization *of an* Instrument Department

By W. H. FORTNEY, Instrument Foreman, Baytown Refinery,
Humble Oil and Refining Co., Baytown, Texas

An organization in industry, whether large or small, may best be described by outlining the basic function, basic equipment, personnel, responsibilities, relationships, and general objectives to be controlled or attained by the individual who heads up the organization. Therefore, this paper will attempt to describe the position of an Instrument Foreman or Instrument Superintendent. Generalities will be used in the discussion of such subjects as basic function, responsibilities, and relationships: these are general and intangible subjects.

Equipment and personnel are tangibles and should be assigned numbers or proportions.

Therefore, we will assume our problem is to organize an Instrument Department for a continuous-processing industrial plant with a capital investment of $50,000,000. This is an arbitrary figure, but it is neither too large nor too small for the major process industries in this country. Using this investment figure, we can include all of the components necessary for a plant with any amount of additional investment; modifications and deletions will permit our organization to be established on a proportional scale for smaller plants.

We will omit the very small plant where the Instrument Department would consist of two or three men; leaving such groups with the comment that many one-, two-, or three-man Instrument Departments are more efficient than the majority of the larger ones.

I. Place in Over-all Organization

An Instrument Department has, by necessity, a wide range of activities. These include work that a few years ago would have been divided up among a number of mechanical crafts, such as machinists, electricians, pipefitters and, to a lesser extent, carpenters, boilermakers, sheet metal workers, welders, etc.

An Instrument Department is equally concerned with operations. Instruments, or at least control instruments, actually operate process equipment. The Instrument Department is certainly a part of any processing industry or unit.

Many Instrument Departments must maintain their own stocks of parts and spares. In any case, some time must be spent in liaison with the Storehouse Department, and therefore the Instrument Department has a storehouse function or responsibility.

The operation of a process may fail or succeed because of the application and design of instrument installations. Application and design are considered engineering functions in most organizations. The Instrument Department has a vital interest in the engineering that goes into a process. The Department therefore has an engineering function which depends, more or less, upon the stability of operation. By this we mean that the engineering functions of an Instrument Department increase as revisions in existing plants are made or in proportion to the amount of experimental and development work carried on in the plant. The same applies to the construction of new equipment. This will be discussed later in more detail.

The Instrument Department has another function usually delegated to a separate division in large organizations; this is inspection. Only the qualified instrument man is capable of inspecting his equipment for accuracy and performance. However, in most cases the Instrument Department has either an assigned or implied responsibility for inspecting its equipment for mechanical strength, corrosion and erosion.

Presented before the Fourth Annual Symposium on Instrumentation for the Process Industries at Texas Agricultural and Mechanical College, October 12, 1949.

Acknowledgement.—Outline of organization adapted from "Top Management Organization and Control" by Holden, Fish, and Smith (Stanford University Press).

There are other staff and line functions, both within the Department and entering into its relations, which set it apart from other organizations in industry.

With this cross section of endeavor it may be difficult to place the Instrument Department in a satisfactory position with respect to top Management, particularly where responsibilities overlap those of other departments.

The actual position in an Organizational Chart is not important unless there are clashes of personality or a top-heavy line organization requiring strict adherence to charts and paperwork.

One Organization Chart might be satisfactory for one group of individuals and completely unworkable when staffed by another group. Since we have the choice, at least in this article, of saying what we like, we will place the Instrument Department Foreman directly under the General Superintendent with a designation of responsibility to the "Operating or Process Superintendent" and the "Mechanical Superintendent." This high position need not overburden the General Superintendent, because we have made the Instrument Foreman responsible to each of the assistants or division heads (titles are sometimes confusing) for the major part of his work or functions. (See Fig. 1.)

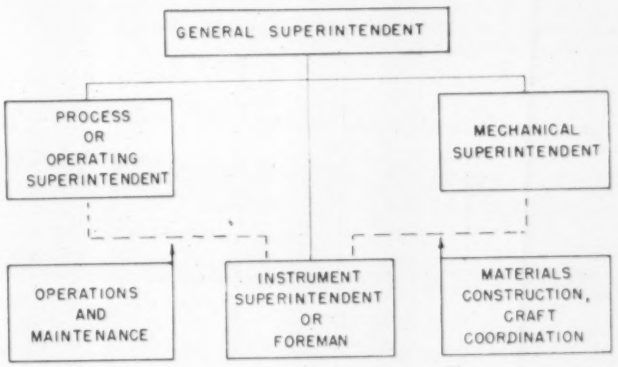

Fig. 1

II. Basic Function

The primary and most "basic" function of an Instrument Department is to install and maintain instruments to measure, indicate, record, regulate, and/or control the environments, qualities and quantities related to the material being processed in the industry. Stated in other words, it is meant that the Instrument Department is a service organization employed by Management to assure the operating division of the plant that measurements of reasonable accuracy and efficient, dependable controls are maintained. The Instrument Department Foreman is Management's immediate director of this service. This basic function extends also to the maintenance of the tools with which the work of the Department is carried on. This means the necessary machine tools, testing equipment, portable and hand tools, and other appliances necessary to perform the work of the Department.

"Instruments," as defined herein, definitely include the control valves and other throttling or positioning devices operated by the instruments.

Another basic function is the maintenance of safe working and operating conditions. This is obtained through selection and training of personnel, inspection of equipment, and the use of protective devices.

The third basic function is development and experimentation. In the minds of some executives this is a debatable subject and in some plants such work is often delegated to other divisions within the organization. For our purposes, this function will remain, for several reasons:

1. Because the development of instrumentation in industry to date is ahead of the colleges and universities. Engineers are not graduated with sufficient understanding of the principles of measurement and control to qualify immediately for application or development work in instrumentation.

2. Because there has been so little research done, even in measurement, that the trial-and-error method is still necessary in a large portion of this work. For instance, although hundreds of volumes have been written on the subject of flow, we do not know of any published data for computing very small or very large flows. The same thing applies to the extremes of temperature measurement; and in electronics. Many leading engineers admit that this latter subject can best be learned with a soldering iron.

3. Because knowledge of the limitations as well as operation of instruments comes from observation and experience.

In any event, research and development work in instrumentation is best carried on "on the job" and those engaged in this work are best informed when intimately associated with the instruments in the field.

It will not be a function of this Department to change disk charts or make calculations of the results shown on these charts.

Design of primary measuring elements, such as orifice plates, will be a function of this Department.

The Engineering Section of the Instrument Department will do the necessary design work where existing equipment is being revised. It will assist in application and design of instrument installations on all new equipment that is installed in the plant; and will have final approval over such.

This much time has been devoted to the argument on placement of at least a portion of the instrument engineering work, because the first-named functions are not debatable; otherwise, there would be no need for a discussion of this type.

III. Basic Equipment

We have assumed a $50,000,000 plant; one-tenth of one percent of this investment may be used in arriving at a rough estimate of the cost of equipment which the Instrument Department needs for efficient maintenance. This will vary, of course, with the size of items being serviced; with the availability in nearby stock of repair parts; and with the severity of service in which the instruments are used. This figure does not include shop building and office space. About 5,000 square feet of shop space should be provided.

The Instrument Shop should have two or more lathes of sufficient size to handle at least 90 percent of its work. At least one tool-room lathe is a necessity. The other machine tools include a milling machine with complete attachments, drill press, grinders, and a pantograph. $30,000 of our $50,000 will be spent for machine tools and their accessories.

The remaining $20,000 should provide the Department with furniture, such as work benches; transportation, including a passenger car and two pick-up trucks; shop handling equipment; hand tools; and test instruments.

Shop layout cannot be given too much attention. There should be facilities to allow a logical step-by-step flow of material to and from the Shop or from there to the operating unit. Outside transportation is usually provided by other departments, but repair costs will be held in line only when those handling instruments and valves have the equipment and "know-how" to see that the items arrive at the Shop and go back to the units without damage. Pallets, low-boy trailers, trucks or carts may be used in handling equipment at both ends of the route; and, when provided, these save in labor costs, personal injuries, and damaged items.

The Shop receiving area should have an external wash-down rack and, where practical, solvent cleaning vats or degreasers. No contaminated or extremely dirty materials should ever be brought into the Shop.

The Shop should be provided with adequate handling equipment, such as jib or traveling cranes; carts, or a lift truck and pallets. The lift truck can hardly be justified unless there is a concentration of other mechanical crafts in the same building.

Test equipment must include certain basic standards. The list may begin with dead-weight gage testers, water columns, test gages, test pumps, portable potentiometers, decade boxes, resistors, Wheatstone bridges, and may continue into conductivity indicators, pH indicators, signal generators, frequency meters, and other calibrating or testing instruments. The number and variety depend upon the measurements required in the industry. Various analytical instruments may also be required; such as Orsats, titrating equipment, etc.

Shop and Field tools are among the most important factors in the work and efficiency of an Instrument Department. Electric and pneumatic hoists save many possible injuries; pneumatic and electric nut runners and impact wrenches afford real savings in manpower and operating efficiency. Jigs, fixtures, and all kinds of holding devices also effect economies in manpower and make for safer working conditions. Each operation that is repeated on a routine basis should be studied to find a better way.

Good instrument mechanics deserve the best in hand tools. A box or socket wrench leaves a bolt or nut in much better condition than a monkey wrench or pair of pliers. The same thing applies to the use of screw drivers; the bit should fit the slot. Pennies saved on hand tools easily grow into dollars thrown in the scrap barrel in the form of damaged parts.

Communication between Shop and Field and the departments being served is important. If the plant is laid out on a spacious scale, it may be necessary to assign automobiles, pick-up trucks, or motor scooters for transporting supervisors, mechanics, or material. Extremely large plants find short-wave radio communication very satisfactory.

IV. Authorized Organization (see Fig. 2)

Our $50,000,000 plant well may require a working force of fifty instrument men, or one man per million dollars of investment. This may be adequate or may be excessive, depending, of course, upon the number, size, and service

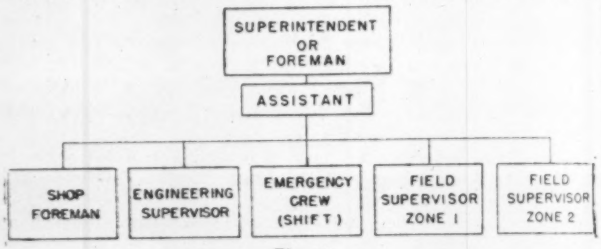

Fig. 2

of the instruments and valves maintained by the Department. An instrument man may maintain two hundred instruments in mild services and be unable to maintain as few as ten identical instruments under severe operating conditions. We cannot attempt to establish every factor in a discussion such as this, and therefore will build around our force of fifty men.

There are two divisions within the working crew; these will be listed as "Shop" and "Field."

Our maintenance and repair will be scheduled and our Shop and Field organization developed with the idea that the Shop itself is the center of activity or nucleus of the Department. In other words, everything will be brought to the Shop whenever this is practical. All instrument men do not agree on this, but in this plant we will so operate.

No attempt will be made to classify men within the divisions. An exception may be necessary to take care of machine-tool operators, such as lathe men, etc. It may even be necessary to use machinists on these jobs.

The remainder of the work includes field installation and maintenance, and Shop repair and calibration.

Shop Organization (see Fig. 3). Assuming fixed assignment on machine tools, four men will be needed for this work. Floor and bench work will require nine men, not including a Shop Foreman or Supervisor. These assignments will vary, of course, with the work load. The Shop should be used to the maximum possible amount in training of new personnel; this is because there is immediate supervision and concentration of work.

Thus we have assigned thirteen of our fifty men to the

Shop. We necessarily have allowed for a certain amount of "catch-all" work that no other department will take or is capable of doing. And every Instrument Department has a share of this. Some departments handle relief valves, others

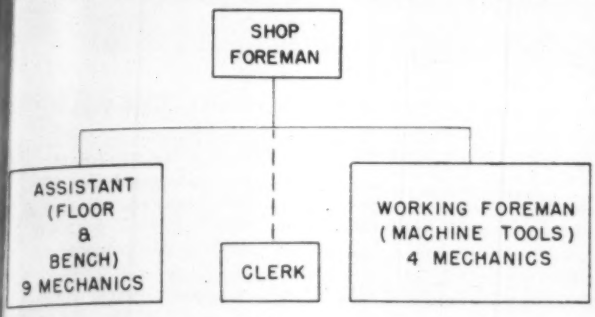

Fig. 3

maintain bicycles, steam traps, padlocks, communication equipment, air-conditioning equipment, and so on ad infinitum.

The Shop Foreman should have a clerk to handle material ordering and receiving, and who will be capable of identifying material coming into the Shop for repairs. This clerk should contact the Field Supervisor or instrument man on details of all routine work from the Field, and should handle the records and work orders, where such are used by the Shop.

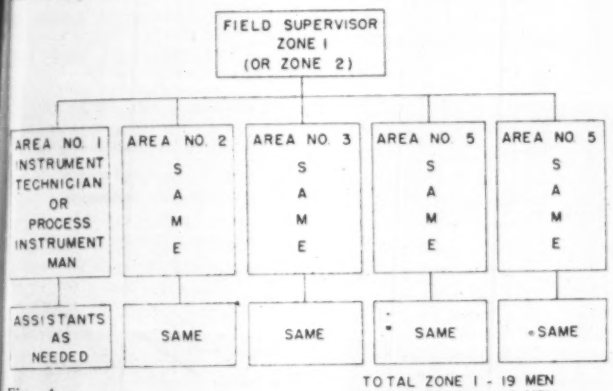

Fig. 4

TOTAL ZONE 1 - 19 MEN
TOTAL ZONE 2 - 18 MEN

Field Organization (see Fig. 4). We must always bear in mind that the entire Instrument Department exists only to serve the process. And the ultimate justification of the Department is based upon the degree of success attained in measurement and control of the processes. In other words, the "pay-off" comes from the Field organization.

Our field organization will consist of thirty-seven men and at least two Field Supervisors. One Supervisor might be able to cover the field crew, if our plant consists only of a number of identical units. On the other hand, if there are a greater number of units processing a variety of materials with no similarity in design, it will be necessary to increase the number of Supervisors.

This works out in actual practice and emphasizes the close relationship between instruments and processing.

In a plant where the units are scattered over a wide area, additional supervision may be necessary because of the "area instrument man."

Various titles have been used, such as "Technician," "Process Instrument Man," "Leaderman," and possibly "Instrument Operator." Whatever his title, the area instrument man is the key to a successful Field instrument operation. He should have a clear understanding of his responsibilities of maintenance and inspection of all instrument items in his area. An area may mean one large unit or a number of smaller units, not too widely separated in the plant layout.

The area instrument man should know enough about the process or processes he covers to be able to discuss them with operators and to distinguish between faulty unit operation and faulty instrument operation.

Unless craft jurisdictional lines are too closely drawn, we expect our instrument men to do all small pipe work, such as meter manifolds; and instrument air tubing installations.

If this work must be done by other crafts, the manpower in the Instrument Department is reduced accordingly and permanent men from other crafts assigned to the Department for this work.

In any event, the area instrument man is responsible for the condition of all instruments and valves within the area he covers. He should be allowed a maximum of freedom in scheduling his work with the understanding that the Process has first call on his services. Preventive maintenance is his responsibility. Preventive maintenance includes: lubrication of valves, meter shafts and moving parts; cleaning; inspection; minor adjustments; repairs; painting; and all of the other chores necessary to keep instruments (or any other mechanical equipment) in operating condition.

Our plant has sufficient variety of operations and a geographical layout such that we have ten "instrument areas" —five to each Field Supervisor. The remainder of the Field crew will form a pool of seventeen men for assignment as needed.

Operations in one or more areas may be such that no additional instrument help is needed; other area men may require from one to four assistants.

For turn-arounds and construction work the manpower pool may be depleted in either Supervisor's zone with a temporary reduction of maintenance work. This should not be done over extended periods of time.

About three men in our pool will be needed to cover time lost from the job by reason of vacation, sickness, etc.

It may be desirable to cover our plant with an emergency man on nights and week-ends; normally this means coverage for sixteen shifts each week; or, three and one-fifth men will be able to handle these repairs, if this work is limited to emergencies. Such an employee cannot be assigned routine responsibilities; and additional supervision would normally be required to obtain productive work from a large crew.

The emergency shift men should report directly to the Assistant Foreman, since this work will overlap the Shop and entire Field.

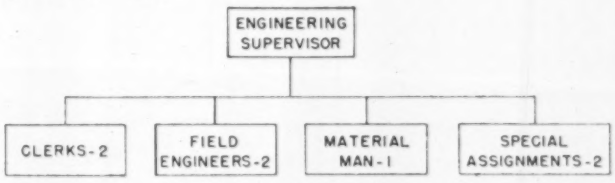

Fig. 5

Staff Organization (see Fig. 5). The next division within the Department is the Engineering and Clerical Section. This group will maintain all departmental records including: personnel files, calibration data, drawings, specifications, parts lists, catalogs, bulletins, etc.

The Section will be responsible for maintaining stock of instruments, valves, and spare parts.

This group will serve both Shop and Field crews in an advisory capacity where problems of design or difficulties in operations are encountered. This advisory service will be extended to Process, Engineering, Testing, Research, and other Divisions in the plant organization.

It goes without saying that the Engineering Group must be interested in new developments, both in instrumentation and in the operations peculiar to the industry.

This group may also be charged with the responsibility of training the departmental personnel in the maintenance of new types of instruments. Its work may even extend into research and development on new instruments. Specially selected non-technical personnel may be assigned to the group when new and complicated instruments are being put into operation. This is especially true of electronic analytical instruments. Too many otherwise competent Instrument Departments in all sections of the country are being found incapable of servicing such instruments as mass spec-

Continued on page 1038

The Development *and* Maintenance *of* CALIBRATING STANDARDS *by an* Instrument Manufacturer

By W. D. WOOD, Director, Standards Laboratory, Taylor Instrument Companies, Rochester, New York

I. Introduction

THE ABILITY of an instrument manufacturer to build accuracy into his product is considerably dependent upon the calibrating facilities available in the plant. These include calibrating standards and calibrating equipment. This article is concerned with calibrating standards. Since several instrument manufacturers produce similar types of instruments and since many users of instruments have standard instruments for checking their working instruments, it is believed that the practices followed by an instrument manufacturer are of general interest.

For many years our company has found it expedient to take a rather rigid technical attitude towards its calibrating standards. The need for this is evident when it is realized that a product can be no more accurate than the standard against which it is calibrated. Many production instruments are calibrated against a single standard so that an error in the standard is costly.

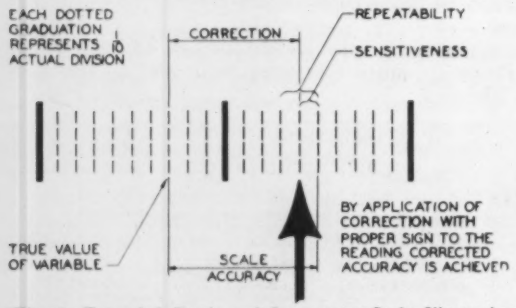
EACH DOTTED GRADUATION REPRESENTS 10 ACTUAL DIVISION
CORRECTION
REPEATABILITY
SENSITIVENESS
TRUE VALUE OF VARIABLE
SCALE ACCURACY
BY APPLICATION OF CORRECTION WITH PROPER SIGN TO THE READING CORRECTED ACCURACY IS ACHIEVED

Fig. 1. Expanded Portion of Instrument Scale Illustrating Repeatability, Sensitivity, and Scale Accuracy.

In line with this policy we have our so-called "Bureau of Standards" which is the Standards Laboratory. One of the functions of this laboratory is to develop and maintain factory calibrating standards against which all product instruments are calibrated. This department, in addition to being responsible for the accuracy of such standards, specifies what standards shall be used for what purposes and instructs the factory personnel in the proper use of the standards. Because of the technical character of the work and its close relationship with product performance, the laboratory is a division of the Engineering Department. The personnel of the laboratory for this type of work includes people who are trained both in physics and engineering.

*Presented at the Fourth Annual Conference of the Instrument Society of America, September 12-16, 1949, St. Louis, Mo.

II. Principles of Selecting Calibrating Standards

The proper selection of a suitable calibrating standard for calibrating a particular product depends on certain inherent qualities of the standard instrument and certain relationships between the standard instrument and the product being calibrated. Five inherent qualities of a standard instrument determine its over-all quality for measuring purposes. I am concerned here with those qualities that relate to the performance of an instrument under steady-state conditions. Since instruments are calibrated under essentially steady-state conditions dynamic characteristics are not of concern in calibrating work. The five inherent qualities of an instrument as a calibrating device are defined as follows:

1. Scale Accuracy: The maximum difference that occurs between the reading of an instrument and the true value of the variable which it measures.

2. Repeatability: The maximum variation that will occur in the indications of an instrument when the measured variable approaches the steady-state condition in any manner.

3. Sensitiveness: The maximum change in the measured variable required to cause a change in indication of an instrument. Sensitiveness is a measure of the amount of friction and play in the moving parts of an instrument.

4. Sensitivity: The ratio of the change in indication per unit input change of the measured variable. In a glass thermometer this would be expressed in inches per degree F. or in a dial pressure gage inches (of the scale arc) per unit psi. The greater the sensitivity of the instrument the more easily can factors of scale accuracy, repeatability and sensitiveness be determined.

5. Drift: Changes with time that may occur in any of the first three factors. Generally, drift can be cancelled out in a calibrating standard by a periodic redetermination of the other factors.

There are, of course, other factors which relate to the utility of an instrument as a factory calibrating tool such as corrosion resistance, ease of op-

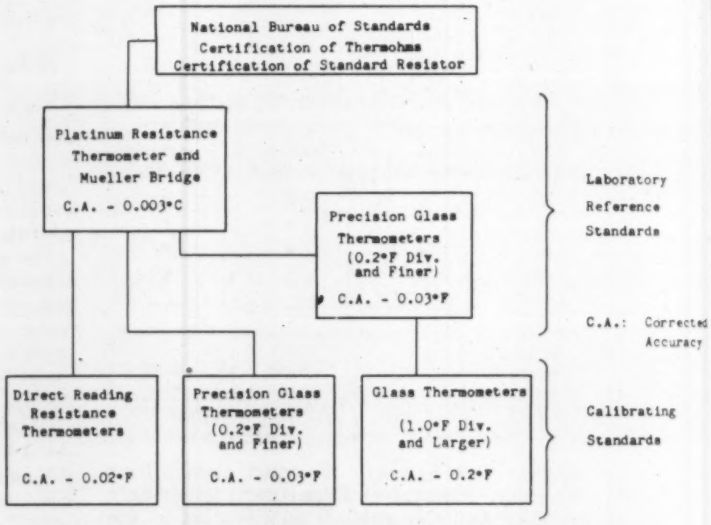
National Bureau of Standards
Certification of Thermohms
Certification of Standard Resistor
Platinum Resistance Thermometer and Mueller Bridge
C.A. - 0.003°C
Precision Glass Thermometers (0.2°F Div. and Finer)
C.A. - 0.03°F
Laboratory Reference Standards
C.A.: Corrected Accuracy
Direct Reading Resistance Thermometers
C.A. - 0.02°F
Precision Glass Thermometers (0.2°F Div. and Finer)
C.A. - 0.03°F
Glass Thermometers (1.0°F Div. and Larger)
C.A. - 0.2°F
Calibrating Standards

Fig. 2. Temperature Standard Relationships.

eration, need for reading aids, etc. but these do not affect its inherent qualities as a measuring device.

In the foregoing definitions the term "scale accuracy" is used rather than just the word "accuracy" in order to differentiate between the scale error in an instrument and the possible accuracy of an instrument when corrections are applied, corrections being determined by comparison with a considerably better instrument. The accuracy of an instrument with corrections applied is here termed "corrected accuracy." Corrected accuracy is not an inherent quality but an instrument is a more valuable standard if its errors are known. Corrected accuracy is defined herewith as the difference in the mean indications of an instrument from the true value of the variable being measured with the correction applied.

It is my feeling that a good calibrating standard is available from the standpoint of its measuring quality provided the foregoing five factors have the fol-

ring values which are expressed in rms of the instrument scale:

Scale Accuracy: Within two and preably one division.

Repeatability: Within one-fifth of a ivision.

Sensitiveness: Within one-tenth of a ivision.

Sensitivity: Conveniently readable to ne-tenth of a division.

Drift: No change in each of the foreing factors greater than one-tenth a division in three months.

Corrected Accuracy: Within one-fifth a division.

The foregoing values can be simply llustrated by reference to an expanded ortion of an instrument scale. (See ig. 1.)

In addition to those inherent qualties which make an instrument a good tandard, there is the relationship beween two of these inherent qualities nd the scale of the instrument being alibrated. These are (1) the sensitivity f the standard should be at least five imes the sensitivity of the instrument eing calibrated; (2) the corrected accuracy of the standard should be less than one-fifth of a division of the instrument being calibrated.

III. The Achievement of Accuracy in Standards

It is of course not always possible to achieve either of the foregoing inherent qualities of the standard or to have available a standard for a particular job with the relative qualities indicated. In practice, better conditions than these are sometimes achieved but in many cases standards selected on this basis are not obtainable.

It is the trend among all users of industrial and commercial instruments to require greater and greater accuracy. To keep up with this demand the instrument manufacturer must not only develop instruments of higher accuracy but he must be increasingly diligent to build better accuracy into his existing instruments, a situation requiring continual improvement in calibrating standards.

The scale accuracy of a calibrating standard depends upon its original calibration. The corrected accuracy is dependent upon intercomparison with a better instrument. Fundamentally, all instruments must relate to ultimate standards of accuracy such as are maintained at the National Bureau of Standards in Washington.

As a manufacturer of instruments we have the choice of submitting our standards to the National Bureau of Standards to obtain corrected accuracy or of making our own direct intercomparison with ultimate standards such as fixed points in thermometry, U-tube and cathetometer in manometry, or dead-weight testers in elevated pressure work. Because of the large number of standards that we use it is expedient to maintain our own laboratory reference standards against which the factory calibrating standards are compared. The reference standards are either submitted to the National Bureau of Standards for certification or compared by ourselves against ultimate standards.

We have found it worthwhile to use certain types of standards as calibrating standards in the factory and other types as reference standards in the laboratory. The relationships between a large portion of our temperature standards are illustrated in Fig. 2. This relationship covers the temperature range for which the International Temperature Scale is defined by the platinum resistance thermometer. At the bottom of each box in the chart is given the corrected accuracy as we estimate it for that class of standard.

Our primary temperature standard is the platinum resistance thermometer and the Mueller bridge. The resistance element or "thermohm" is certified at the National Bureau of Standards at the oxygen, ice, steam, and sulphur points. The Mueller bridge is certified by us by intercomparing the resistance of its decades with a standard resistor certified at the Bureau. With the certification constants and a reading on the bridge with the "thermohm" in a precision ice bath, an interpolation table is derived for the particular bridge and "thermohm" combination, in accordance with the International Temperature Scale relations defined by the Callendar and Van Dusen equations.

In addition to the resistance thermometer as a laboratory reference standard it has been found expedient to utilize several precision thermometers graduated 0.2 F. and finer for certifying those working standards graduated 0.5 F. and rougher. The more accurate temperature calibrating standards, including direct-reading resistance thermometers and precision type glass thermometers, are certified directly against the laboratory primary resistance thermometer standard.

Fig. 3 gives the relationship between pressure standards. In pressure work the U-tube and cathetometer serve as a reference for determining pressures below 25 psi. and the dead-weight tester for pressures above 25 psi. With a good U-tube and cathetometer set up on concrete ground floor with steady ambient conditions, precise pressure measurements can be made utilizing basic physical relationships. It is not ordinarily necessary to refer a dead-weight tester to the National Bureau of Standards for certification unless extreme accuracy is required. Whether or not a dead-weight tester is within its guaranteed accuracy can usually be checked quite readily by the user. The diameter of the piston can be checked with Johansson blocks and the weights can be precisely weighed. The need for referring such a tester to the Bureau would only be where the greatest precision is required. The Bureau's service would be to determine the effective area of the piston at different pressures.

In some instances it is necessary to utilize as calibrating standards instruments which have been certified at the National Bureau of Standards. This

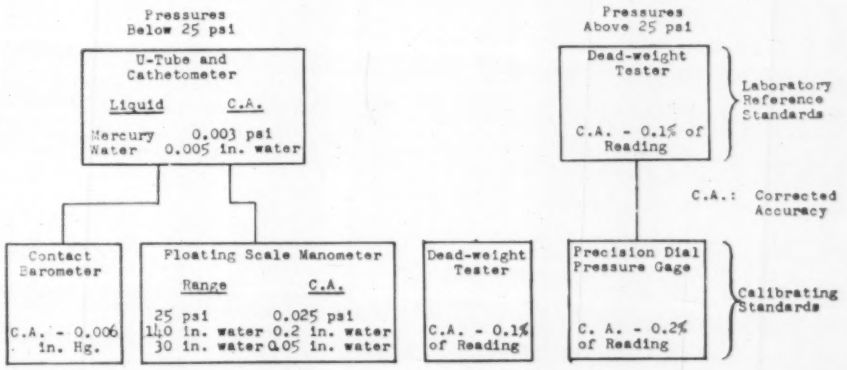

Fig. 3. Pressure Standard Relationships.

arises because the accuracy of the product is such that there is little leeway between the accuracy of the best available standard and the product itself. Three types of our standards that fall into this category are anemometers, hydrometers, and partial-immersion A. S. T. M. thermometers. These standards are known as like product standards because the standard both in range and dimensions is exactly like the product for which it serves as the calibrating standard. There is often not even a good approach to the desired relationship between the corrected accuracy of the standard and the allowable scale accuracy of the product. For instance, with some A. S. T. M. partial-immersion thermometers which are standardized at the National Bureau of Standards, the National Bureau of Standards gives corrections only to the nearest one-half division and the manufacturer is required to produce an instrument accurate to one division or better.

There is, however, one compensating feature in using like product standards. The calibrating equipment does not need to be of as high a quality as that used in certifying the standards at the Bureau since disturbances would be equally experienced by the standard and the product and therefore cancel. Thus a manufacturer can use a relatively simple wind tunnel and yet calibrate his product in terms of the conditions of certification at the Bureau. Or with a partial immersion A. S. T. M. thermometer the manufacturer's calibrating liquid bath does not need to reproduce the emergent-column

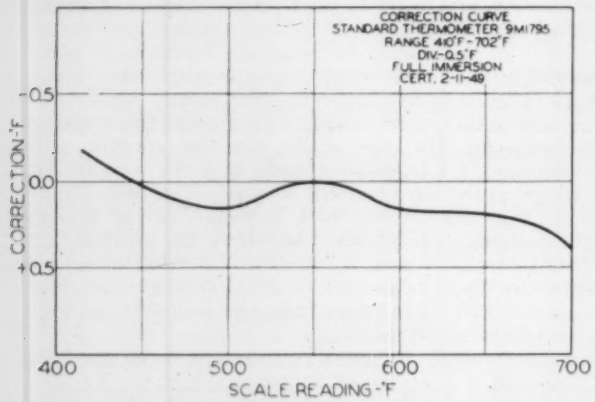

Fig. 4. Correction Graph for Standard Thermometer.

conditions specified by the A. S. T. M. since these conditions are achieved in the certification at the Bureau.

The foregoing discussion relates to the achievement of accuracy initially in reference and working standards. Accuracy is maintained thereafter by a periodic check for drift either by recertification or check at one point. The type of drift check depends on the standard.

The primary resistance thermometer is drift checked by an ice-point check each time it is used for certification work and by a check at the benzoic-acid point every four months. Calibrated benzoic acid cells for this purpose are obtainable from the National Bureau of Standards. Benzoic acid has a freezing point of approximately 122.36 C. The Bureau calibrates individual cells to the nearest 0.001 C. with accuracy stated to the nearest 0.003 C. The use of such a cell for a fixed-point check is much simpler than the steam point.

Working glass thermometer standards are checked for drift by an ice-point test. Any shift in the ice point is reflected by an equal shift at all certification points. Modification of the corrections accordingly is as good as a complete recertification of the thermometer.

In a pressure standard such as a dead-weight tester or manometer, drift does not take place if there is no wear and components are kept clean. In a dial pressure gage standard, it is desirable to recertify at intervals of six months or one year, depending on the amount of use.

IV. The Processing of Standards

Calibrating standards are purchased or custom-built. They are then certified against reference standards in the laboratory except in those cases where they are submitted to the National Bureau of Standards. They are next issued as needed along with a table or graph of corrections. Thereafter they are periodically checked to assure that initial accuracy is being retained.

The documents written and the records kept in relation to these operations serve to indicate the steps in handling calibrating standards. These are listed with their purpose as follows:

1. *Instructions Covering Policy:* There is a write-up for each class of standard (thermometers, hydrometers, anemometers, etc.) which covers the policy of the laboratory relative to the types of reference and calibrating standards maintained. It includes statements of certification and follow-up activities and indicates the types of records kept. This document informs interested persons in the company of the laboratory policy and serves as a directive to the laboratory personnel in processing that particular class of standard.

2. *Standard Card:* A reference card is filled in for each standard, giving description, identifying number, cost, latest certification date, etc.

3. *Instructions Covering Certification Procedure:* These instructions give in detail for each class of standard the technique followed in comparing calibrating standards with reference standards in order to obtain a set of corrections for the calibrating standards.

4. *Original Data:* All original data taken in certification work are filed for future reference.

5. *Certificate of Corrections:* A certificate is filled in and filed in the laboratory listing the corrections at the various test points for each standard certified. These corrections when applied to the reading of the standard give the value of the variable being measured.

6. *Graph or Table of Corrections:* A graph or table of corrections is made up depending on the application of the standard. Such corrections are issued with all standards. For a glass thermometer which may be used at any point over the scale a smooth curve drawn through the test points provides the best correction form. A typical correction curve is shown in Fig. 4.

STANDARD NUMBER 9M762

RANGE 25 to 75°F in 0.2° div. DEPT. 13

WORK TO BE DONE Check ice point every three months. Period of check may be increased successively to six months and one year periods provided the successive checks for each period show no drift greater than one tenth division.

DATE	ICE POINT CORR.	REMARKS	DATE	ICE POINT CORR.	REMARKS
10-5-46	-.10	certified			
2-10-47	-.10	issued			
4-22-47	-.10	checked J.F.			
8-1-47	-.12	checked J.F.			
11-4-47	-.14	checked J.F.			
11-4-47	-.14	corrections changed			
2-5-48	-.16	checked J.F.			
5-10-48	-.14	checked J.F.			
8-1-48	-.14	checked J.F.			
2-3-49	-.16	checked J.F.			

Fig. 5. Follow-up Card for Glass Thermometer Standards.

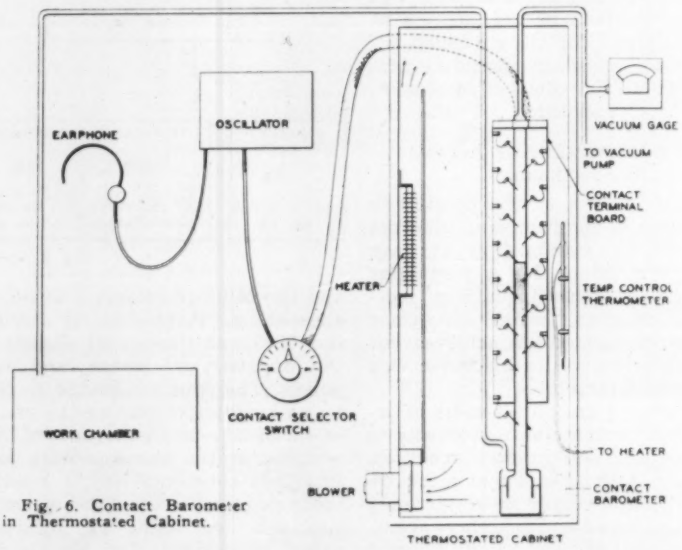

Fig. 6. Contact Barometer in Thermostated Cabinet.

7. *Follow-up Card:* This card indicates the procedure followed in the periodic rechecking of each issued calibrating standard. Fig. 5 illustrates a typical follow-up card for a glass thermometer standard where an ice point check is made to detect drift.

V. Special Standards

A manufacturing company such as ours has in continuous use a large number of calibrating standards. Improvements in ease of manipulation or readability are advantageous if at the same time desirable relationships between standard and product of sensitivity and accuracy can be achieved. We have found it worthwhile to utilize special standards in several instances. Three examples of such developments are described.

Fig. 6 illustrates a contact barometer which is used to adjust the pressure in a work chamber in which several barometric instruments are placed for calibration. The barometer is a glass cistern type instrument with tungsten contacts inserted along the upright leg. The contacts may be inserted at inch or half-inch pressure steps. By flaming the seal between the contact and the

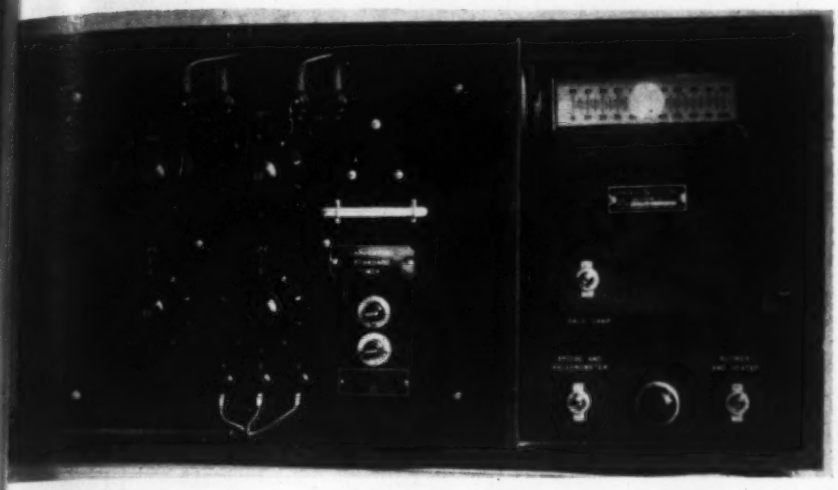

Fig. 7. Direct-reading Resistance Thermometer.

glass the position of the contact point may be adjusted to a thousandth of an inch to eliminate scale corrections. The selector switch is set to the desired pressure and the operator adjusts the work-chamber pressure until she hears a steady making and breaking (caused by equipment vibration) of the oscillator signal. The contact barometer is calibrated and used in a thermostated cabinet to eliminate the effects of change in ambient conditions. A particular advantage of this standard is that an audible signal indicates the correct pressure permitting the operator's visual faculty to be confined to the product.

Fig. 7 illustrates a direct-reading resistance thermometer. The resistance bridge, platinum "thermohm," and galvanometer are purchased. We mount the bridge in a thermostated cabinet so that ambient changes will not affect bridge decade resistances. The advantage of these instruments include long range and high sensitivity. With direct-reading dials an operator will rarely make an error in reading the standard. We have such standards with range spans up to 800 F. operating between —325 F. and 1000 F. Their sensitivity varies from 1 to 2.5 mm. galvanometer reading per hundredth degree F. Were 16-inch glass thermometer standards of equal sensitivity used to cover a 500 F. span, one would require about two hundred and fifty standards of successive ranges. Of course, glass thermometers that sensitive are not practical but even for precision glass thermometers graduated in tenths of degrees F., read with the aid of a telescope, approximately fifteen glass standards would be required to cover a 500 F. span.

Fig. 8 illustrates a floating-scale manometer* mounted in a thermostated cabinet. The manometer consists of an upright tubular metal leg at the base of which a cylinder provides an annular cistern. The liquid in the tube supports a partly submerged float on which rests a length of square tubing. The

*Design of floating-scale manometers described in detail in paper at Second I.S.A. Conference, Chicago, Sept., 1947.

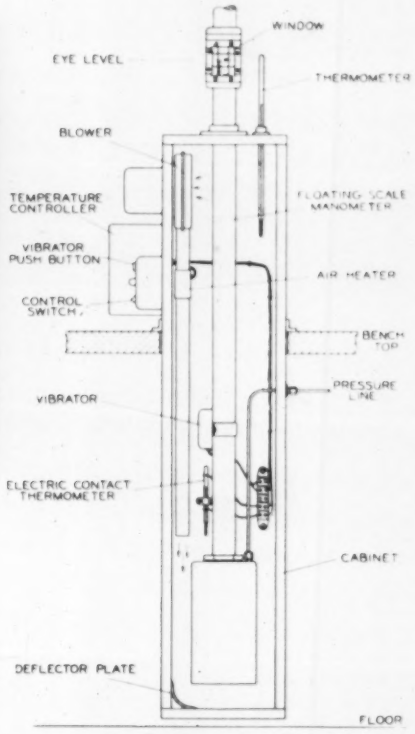

Fig. 8. Floating-scale Manometer in Thermostated Cabinet, Cabinet Front Removed.

scale is engraved on the square tubing and the instrument is read through a window in the upright tube. The liquid used may be of mercury, tetrabromoethane, or oil, depending on the range desired. Instruments with ranges of 30 in. water, 150 in. water, and 25 psi. are used. Good sensitivity is obtained as scale lengths vary from 30 inches to 45 inches. The singular advantage of this instrument is constant reading height. It can be mounted through a bench top. The instrument can be read by the operator in a seated position while calibrating a product instrument on an adjacent easel.

ROCKET APPLICATIONS *of* Electrostatic Generating VOLTMETERS

By JOHN F. CLARK, JR., Naval Research Laboratory, Washington 25, D. C.

I. Introduction

An electrostatic generating voltmeter is often calibrated to measure the potential difference between two objects, from one of these objects, when their relative positions are fixed. More precisely, it is an electromechanical device which measures the electric field intensity, in volts per meter, in the direction in which the instrument is pointed. It may be used to measure high d-c. potentials,[1] as a rugged electrometer,[2] as as an aircraft potential indicator.[3] It might be used to measure electrostatic potentials on insulated conveyor belts which transport materials in a potentially explosive suspension of dust. In such use, the generating voltmeter could be arranged to shut off the belt-drive motor when the belt potential exceeds a safe value. Numerous other similar applications require a quick, safe means of measuring static charges or high potentials without drawing current from the potential source. In 1946, the use of the electrostatic generating voltmeter to measure aircraft potentials, which were correlated with precipitation static, was reported.[4] It seems reasonable that if corona is a problem on aircraft, it might be even more of a problem on rockets.

By a suitable distribution of several electrostatic generating voltmeters over the rocket skin, it is possible to separate the field due to a charge on the rocket from that due to potential gradients already existing in regions above the

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earth. The instruments which have been developed since 1947 by the Ionosphere Section were intended for such use. Of the rockets fired at the White Sands Proving Ground since 1947, five V-2's and one Aerobee were each equipped with at least one generating voltmeter. The principles and characteristics of the most advanced equipment are discussed in this article. Results obtained during rocket firings will be reported elsewhere.

II. Theory of Operation

Fig. 1 shows a block diagram of the generating voltmeter. The rotor consists of six blades and rotates at the rate of 5000 r.p.m. It may be shown that if the input impedance is essentially capacitive, then the peak-to-peak value of voltage developed across the input capacitance C, as the uncovered stator area varies from zero to A, is $(K_0AE)/C$, where K_0 is the permitivity of free space (8.84×10^{-12} farads per meter), A is the total stator area (6.0×10^{-3} square meters), C is the input capacitance (1.0×10^{-10} farads), and E is the incident electric field intensity in volts per meter. K_0 is a universal constant, while A and C are constants of a given instrument. Thus, the peak-to-peak amplitude of the sawtooth voltage is 5.31×10^{-4} volts for a field of 1 volt per meter, and varies linearly with the applied electric field. The peak value of the fundamental component of the above voltage is $4/\pi^2$ of this value. Its frequency is 5000 r.p.m. $\times$ 6 blades/60 sec. per min., or 500 c.p.s. Consequently, the fundamental component of the developed voltage equals $2.15\times10^{-4}\ E \sin 1000\ \pi t$. Measured values of developed voltage are generally about 90% of the calculated value above. The difference is probably due primarily to fringing of the electric field around the rotor.

III. Physical Characteristics

Fig. 2 shows a view of the generating voltmeter head with its associated amplifier and power supply. The entire equipment is powered by a 24-volt battery. A dynamotor provides the plate supply voltage. Twelve-volt filament tubes are series-connected in pairs, to decrease voltage drops in the long connecting cable between the head, which is often located in the midsection of the rocket, and the amplifier chassis, which is usually located in the nose section. The complete equipment weighs 17 pounds and requires 100 watts of power at 24 volts. The head dimensions, total weight, and required power could all be materially reduced for other installations with such requirements. The instrument is built essentially in accordance with naval shipboard specifications regarding shock, vibration, and temperature variations.

Certain conditions of vibration, acceleration, and temperature which exist in V-2 and Aerobee rockets may be of interest. The maximum steady acceleration of the V-2 is 6 to 8 g. Vibration in the warhead has been measured as approximately 0.01 inch maximum excursion at approximately 50 c.p.s. However, in the tail section near the motor, indirect evidence indicates much larger amplitudes. These considerations dictated the choice of the warhead as the most favorable location for the amplifier chassis. On the other hand, mechanical forces and stagnation temperatures may be expected to be worse at the nose, where the first shock wave originates at velocities above Mach 1. For this reason the exposed heads were located in the midsection of the V-2. Conditions in the Aerobee are similar, except for an initially greater sustained acceleration due to the booster action, with correspondingly greater velocities at lower altitudes. At no time has there been any evidence of malfunctioning of the generating voltmeters due to these rocket flight characteristics, nor have the generating voltmeters caused any observable damage to the rockets. After one V-2 flight of 100 miles in altitude, both generating voltmeters were recovered undamaged, and were subsequently re-used. On this flight, the rocket reached a peak velocity in xcess o 3000 m.p.h. at an altitude o approx mately 100,000 feet.

IV. Electrical Characte stics

Several vexing problems ere en countered in developing a suit ble elec trostatic generating voltmet . First since the equipment is unatte ded dur

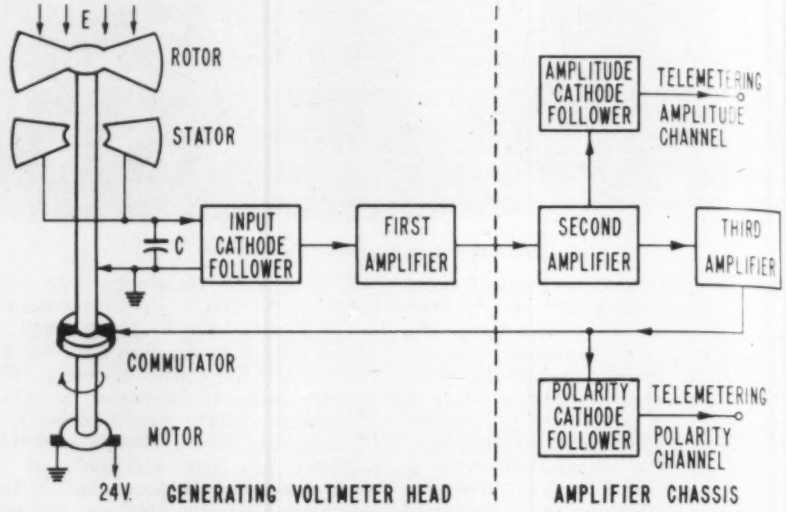

Fig. 1. Block diagram of the electrostatic generating voltmeter.

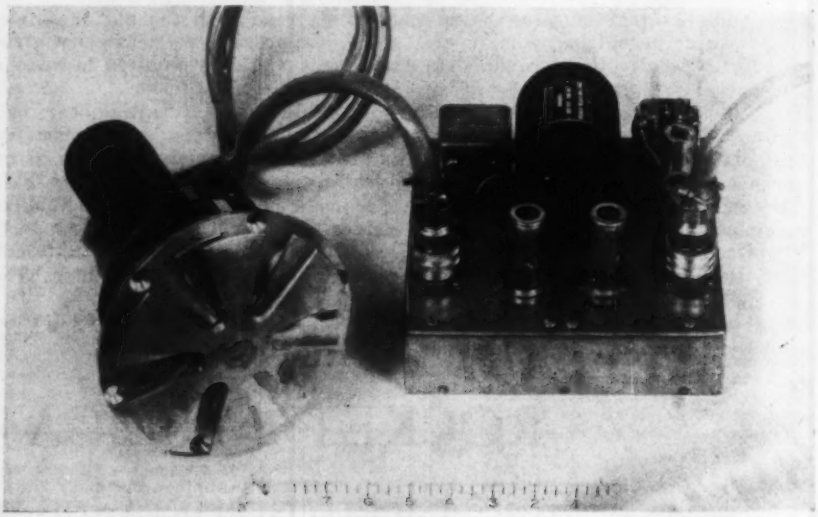

Fig. 2. The electrostatic generating voltmeter, showing the head, the connecting cable, and the associated amplifier and power supply chassis.

ing normal use, the dynamic range of perhaps 1 to 10,000 volts per meter must be compressed to the telemetering voltage range of 0 to 5 volts d.c., for transmission to ground telemetering recorders. Second, field changes must be followed accurately within perhaps 0.1 second, owing to the rapid field changes which might be expected to accompany high rocket velocities.

Referring to Fig. 1, the input cathode follower serves to transform the impedance presented to the input voltage to a lower value. The signal is amplified by the first amplifier in the head and then fed to the separate amplifier chassis. The second and third amplifiers increase the signal amplitude still

rther. The total amplification in the ead is a factor of 5. The maximum am- ification on the separate chassis is ap- roximately 2000. AVC voltage de- veloped at the grid of the third ampli- er is used to control the gain of the

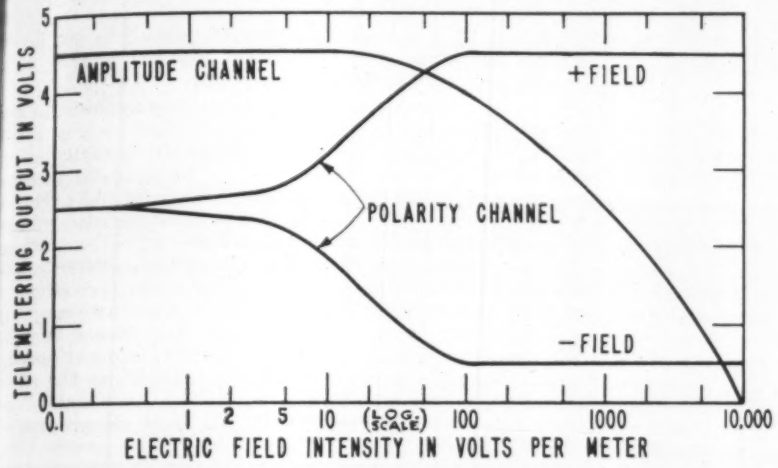

Fig. 3. Typical calibration curves of the electrostatic generating voltmeter.

econd amplifier, and is also fed through the amplitude cathode follow- er. It is the time constant of the AVC ilter circuit which determines the over- all time of response as 0.1 second, which is 5 *RC* constants. The amplitude cathode follower provides an accurate indication of larger field strengths, rom 50 to 10,000 volts per meter, as hown in Fig. 3. The third amplifier, in conjunction with the commutator, oper- ates as a synchronous amplifier. In ef- fect, either a positive or negative peak of the amplified signal, depending on the polarity of the applied electric field, is momentarily switched to ground at the same instant of each cycle, by the commutator. The a-c. component of the resulting pulsating voltage is filtered by an *R-C* network at the grid of the polarity cathode follower. This circuit is a peak-reading voltmeter which gives a reliable measure of the amplitude of small fields, from 1 to 50 volts per meter, and of the polarity of any field strength greater than 1 volt per meter, as shown in Fig. 3. This type of calibra- tion is accomplished by means of a cali- brating plate placed parallel to the stator assembly. The impressed electric field is determined by dividing the ap- plied calibration voltage by the spacing between the stators and the calibrating plate.

The accuracy to be expected from such a device depends largely on its in- tended application. For the present pur- pose, an extended dynamic range is far more important than accuracy better than perhaps 5 percent absolute. On the other hand, for a restricted dynamic range and with special attention to calibration procedures, absolute accur- acy of better than 1 percent should be readily attainable.

Acknowledgements: This project has been under the direction of T. R. Bur- night from its inception in 1947. W. F. Fry, G. S. Van Sickle, and C. V. Strain contributed to the development of the early rocket-borne generating volt- meters. R. E. Bourdeau has ably as- sisted in the development of the more recent models.

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"Reports" should not be padded with a number of charts and tables copied from books, journals, etc.; pertinent abstracts suffice. "Essays" must not exceed one thousand words. Brevity and conciseness will count in grading all entries.

Each contestant may submit as many different entries as he desires.

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Authenticity: Source of data should be given. Manuscripts made up of assertions, figures, charts, etc.—even the most impressive—risk being disqualified if the facts and figures are not verifiable. After the judging, all manuscripts receiving Prizes or Honorable Mentions will again be checked for accuracy and authenticity before the list of winners is made public.

All "essays," and all textual portions of "reports," must be typewritten, with lines double-spaced or triple-spaced, on one side of the sheet. All charts and other drawings must be in India ink on white paper or clean tracing cloth, suitable for black-and-white reproduction. (No pencil-shaded areas or other treatment that would blur.) Hand-written and single-spaced typewritten essays will not be considered. All entries must be addressed to **Contest Editor, Instruments Publishing Co., 921 Ridge Ave., Pittsburgh 12, Pa.**

The Judges' ratings will be based upon: pertinency of factual data (closeness to the theme); value of information presented (breadth of applicability to problems faced by various industries); timeliness, novelty, originality, etc.; and effectiveness of presentation.

Manuscripts and illustrations become the property of the Sponsor and are not to be returned. The Sponsor reserves the right to publish any article submitted, whether prize-winner or not, and to exercise the privilege of editing each manuscript. Most will be published in *Instruments*; others—especially those of interest to specific industries, may be published in special-scope magazines. Due credit will be given to the author of any article which is published after the selections are made.

Contest closes Saturday, December 31, 1949. All entries must be in the office of The Instruments Publishing Co. on or before that date. Don't forget that the envelopes must be addressed to "Contest Editor."

The articles resulting from this contest will appear in the earliest possible issues of *Instruments;* also some of them may be printed in other periodicals—wherever they will promote the adoption of the latest methods of boosting productivity.

Every reader who knows of one or more ways of using instruments to cut costs is urged to enter the contest. The rules have been made easier than in our previous contests. It isn't as hard as you think! Read the rules and start preparing your entry—or entries!

Some Application Factors Affecting *the* Regulation *of* pH *in* Industry

By ALLEN L. CHAPLIN, Consulting Engineer

VI. SOME TYPICAL AND APPROVED pH CONTROL INSTALLATIONS.

(Continued)

(C)

At the Fourdrinier paper machine pH control presents no major difficulties beyond physical limitations. Buffer index is low and compensates for many objectionable conditions which would otherwise make control difficult. The major source of trouble is equilibrium lag; in fact it is almost the only condition which must be reckoned with and the problems of application are primarily concerned with avoiding it.

Figs. 65 and 66 are typical examples of control applications under representative conditions of machine layout.

Fig. 67 is another typical layout and is presented here to bring out a very important condition existing at the machine. Ordinarily, the purpose of regulating pH at the machine is to establish optimum pH at the wire for flocculation and drainage, etc. It is not possible to regulate pH directly at the wire for several reasons pertaining to equilibrium lag and it is necessary to go back farther in the process for application of the regulator. pH at the wire is not the same as pH at other points in the system and allowances must be made for the difference. In other words, the regulator set-point must be adjusted appropriately to maintain desired pH at the wire. The graphs included in Fig. 67 indicate the relationship between pH at the stuff box and electrodes for one specific machine installation. The relationship is not linear and the magnitude of compensation required depends upon actual setting of the regulator set-point.

Note also the behavior of concentration gradient at the various points indicated on the machine layout in Fig. 67. It is particularly significant that although pH is controlled at 5 pH at the electrodes (point "D"), it increases to an equilibrium value of 5.6 pH at the head box (point "E"). This is not an unusual condition and is not characteristic only of the paper machine. It is characteristic of all continuous processes which, as before said, are *distance-concentration* systems. The concentration of one constituent is constant at any point in the process with respect to time but changes in magnitude with forward displacement. Figs. 68 and 69 illustrate how this general condition applies to a paper-making process. The addition of alum to the beaters has the effect (among other things) of adjusting pH of the "furnish." As pulp moves out of the beater and on through the process, its

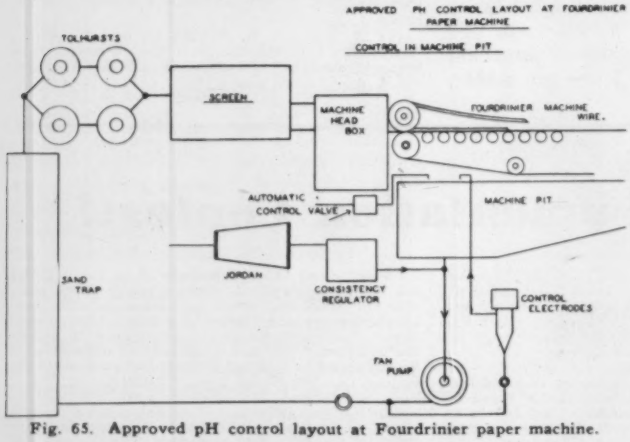


Fig. 65. Approved pH control layout at Fourdrinier paper machine.

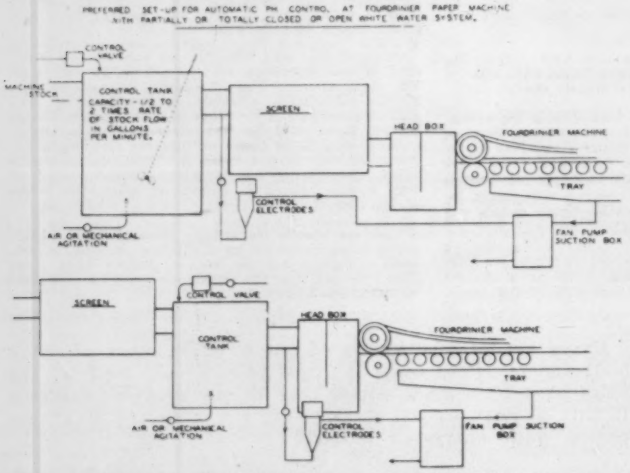


Fig. 66. Schematic illustration of approved installations of pH control at Fourdrinier paper machines.

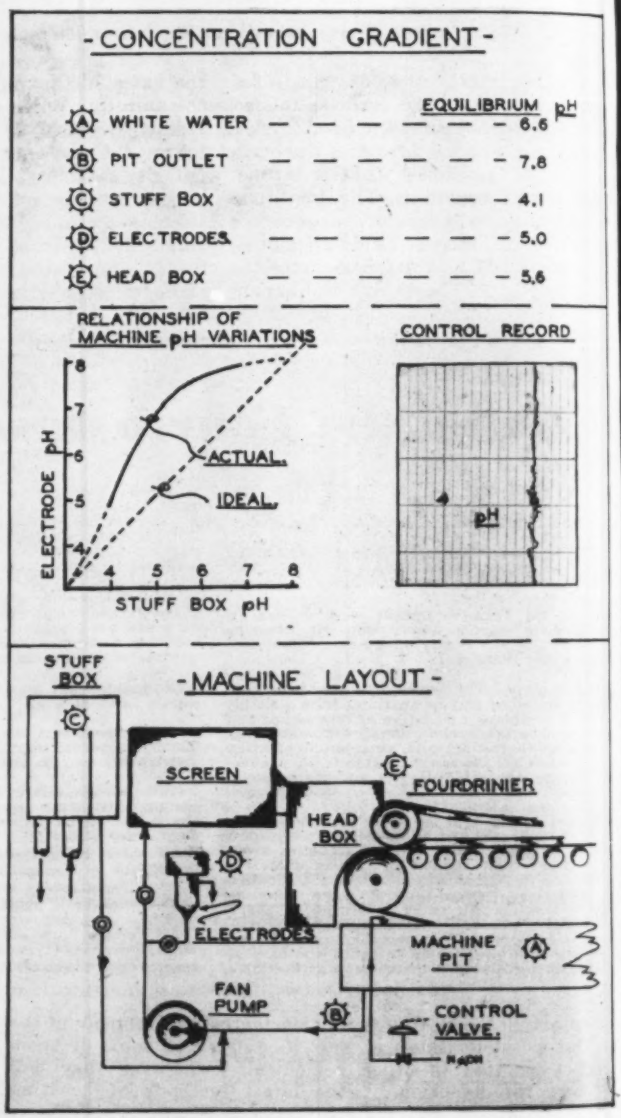


Fig. 67. Typical paper machine control layout showing effects of CONCENTRATION GRADIENT and relationship of machine pH variations with influx load changes.

pH changes. For example, a 4.0% alum "furnish" yielded a pH of 4.9 at the Jordan engines, 6.0 at the machine and 6.5 at the tray. pH (concentration) remains fairly constant at these respective points but changes, as indicated, with forward displacement. The importance of this concept cannot be overstressed in the analysis of any continuous process.

The points on the curves of Fig. 68 represent the general averages of a large number of measurements made simultaneously at the points indicated. The figure is representative of a special process and is not necessarily characteristic of all paper mills. It is not ordinary practice to operate at the high pH ranges of the process represented; but, irrespective of actual pH values obtained, all continuous processes behave in this manner with respect to some one constituent. The spread of pH differences is smaller for most paper processes and may be larger for others, but each will have a characteristic spread.

It is of further interest to note the difference in rate change at the three points indicated as evidenced by differences in slope of the curves. This simply means to the control engineer that a pH regulator applied at one point in a continuous process will not react at the same rate change as it would at another point in the system. If a regulator is applied at one point, as a matter of convenience or necessity, to control pH at another point, it may not necessarily control at the same pH desired at the remote point; and, furthermore, since the process responds at different rates with forward displacement, the control band at the regulator is not necessarily representative of band width at the remote point.

The impracticability of measuring and/or regulating pH at the wire necessitates remote installations as indicated in the many diagrams. In some cases, it is customary practice to base operations on tray-water pH but this is not fully representative of wire conditions, nor is it advisable to install electrodes at this point and regulate reagent feed to the head box or screen because of equilibrium lag resulting from preferential absorption of acid constituents, by the pulp fibres as described in connection with Fig. 27.

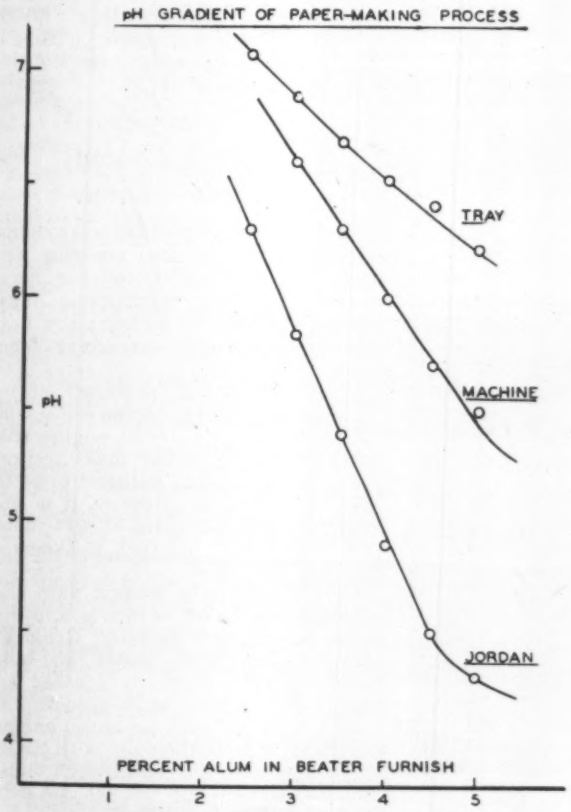


Fig. 68. Effect of process displacement on pH control. pH may be regulated satisfactorily at one point in the process but fundamental principles of CONCENTRATION behavior may cause the effect to change at succeeding points in the system.

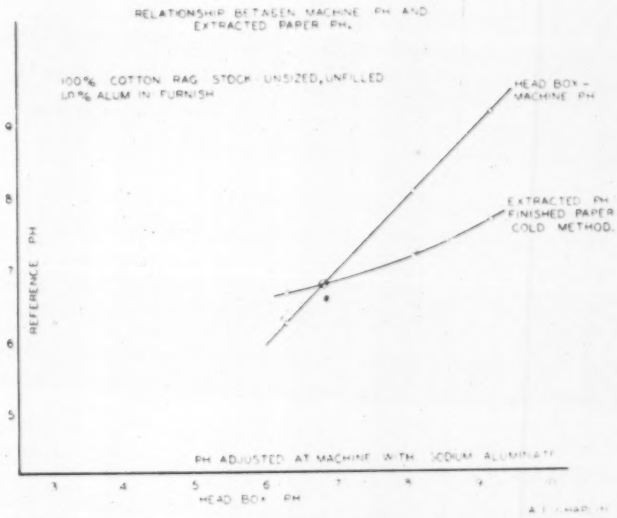


Fig. 69. Extension of pH relationship illustrated in Fig. 68 to points beyond the machine. Characteristic reverses at machine wire, and extracted paper pH drops below head-box pH and increases only slightly with increasing machine pH.

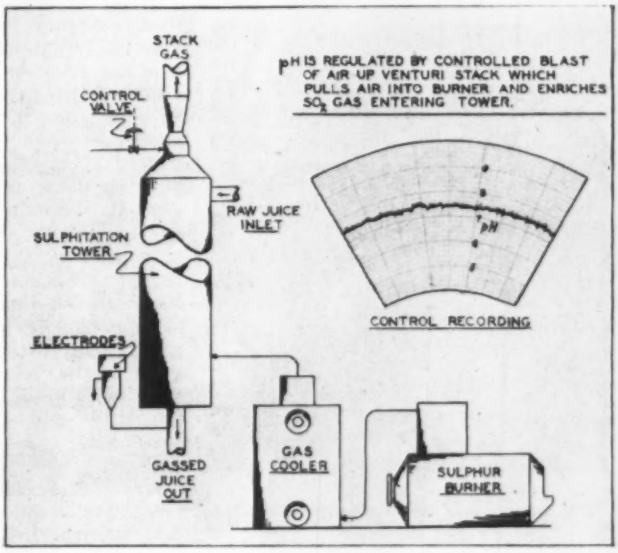


Fig. 70. Control of pH of typical high-residence beet sugar sulphitation process.

(D)

Sulphitation of beet-sugar juice presents an interesting control application. This process is being largely replaced by more modern ion-exchange methods which also require pH control but only the sulphitation process will be described at this time.

Neglecting other instrumentation required for flow and temperature control, etc., the pH application illustrated in Fig. 70 is typical. Raw sugar juice enters at the top of a packed column and trickles downward counter-currently to uprising SO_2 gas; a scoop collects a sample of gassed juice for the electrodes. Flow of gas through the tower is effected by controlling a blast of air through the nozzle of a Venturi in the stack; and changes in stack draft enrich the incoming gas by pulling more air through the rotary sulphur burner.

Notwithstanding the crude control of gas concentration and the large supply-side capacity lag, the stability of pH control is good because of low buffer index of sugar juice. The major limitation of this application lies in the high-temperature juices which necessitate frequent electrode maintenance.

Fig. 71 is a schematic illustration of another beet sugar sulphitation process having supply-side capacity lag similar to the first. The sulphur stove is a closed unit and concen-

Continued on page 1040

INSTRUMENTS ON THE MARCH

Frequency-monitoring System *for* Interval Timers

WASHINGTON, D. C.—A frequency monitoring system devised by R. E. Gould and H. A. Bowman of the National Bureau of Standards now provides a means by which any Bureau laboratory may obtain the proper correction to be applied to a commercial interval timer driven by the city power line. The system, which depends on a frequency error indicator designed at the Bureau, is simple and straightforward in application, offering a minimum of opportunity for error in the correction given.

Interval timers driven by synchronous motors connected to the power line are widely used in science and technology for timing radiation counters, fluid flow in hydraulics, viscosity measurements, chemical reactions, ballistics experiments, and high-speed photography. Yet one serious disadvantage in their use has been the error caused by variations in the frequency of the current in the local power system. Use of a frequency error indicator has eliminated this difficulty at the Bureau; similar devices should prove of advantage elsewhere.

The Bureau's design makes use of the difference in speed of rotation of two 60-cycle synchronous motors, one driven by the power line and the other by a standard crystal-controlled frequency. The two motors are connected to a differential gear system. The angular velocity of the differential gear shaft thus depends on the departure of the power line frequency from the standard frequency. Two standard frequencies would hold the gear shaft motionless. The position of this gear shaft at any instant depends upon the total integrated frequency error of the power line at that instant. This shaft is connected to indicating dials which are calibrated to give the cumulative error in seconds and hundredths rather than in cycles

In practice, the individual at the Bureau who wishes to time an experiment may call the Bureau's time laboratory both at the beginning and end of the experiment to obtain the correction given on the dials of the error indicator. The initial and final corrections, each a positive number, are then added to the initial and terminal observations, respectively, of the interval timer that is used. The difference between these two sums is the actual duration of the interval measured. Since the cumulative error seldom drifts faster than 0.3 second per minute, the correction received by any Bureau laboratory in this way is precise within a few thousandths of a second. An automatic recording device operated in conjunction with the system provides a complete charting of the frequency variation over the time interval when desired.

Fig. 1. Close-up of the NBS frequency monitoring device. The cumulative error is obtained by comparing the speeds of the two small black synchronous motors (just right of center), one driven by the power line, the other by a standard crystal-controlled frequency. Any difference in the speeds of the two motors results in motion of the differential gear mounted on the shaft between them. The position of this gear shaft at any instant thus depends upon the total accumulated frequency error in the power line at that instant. The shaft is connected to the indicating dials. A transmitter Selsyn (center right) transmits the angular motion of the differential gear shaft to a receiver Selsyn (not shown) which operates the recorder. The power amplifier in the foreground amplifies the Bureau's crystal-controlled standard frequency to drive the standard motor.

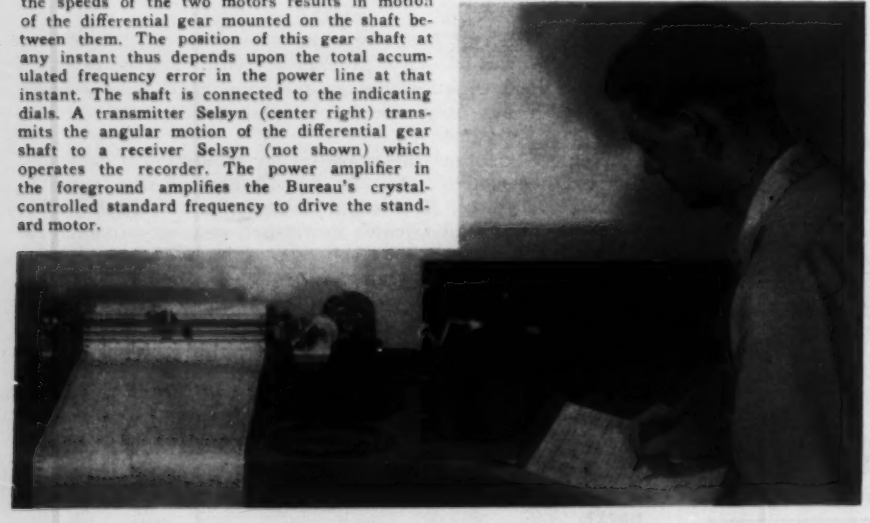


Fig. 2. NBS frequency monitoring device whereby any Bureau laboratory may obtain the proper correction to be applied to a commercial interval timer driven by the power line. The cumulative error may be read, both at the beginning and end of an experiment, from the two dials in the panel board; or, if desired, a complete charting of the frequency variation over the time interval may be made on the automatic recorder at the left.

POSTWAR RADAR applications include use of centimeter waves for gas analysis and for meteorology (automatic cloud-height recording, etc.). Automatic transmit-receive switch, vital to these radar equipments, is shown above hand of laboratory worker as she tests it in waveguide system.—*(Photo courtesy Sylvania Electric Products Inc.)*

Engine-noise-study Instrumentation

CHICAGO—By putting noisy engines into a padded cell and studying what parts are responsible for the nerve-wracking decibels, scientists at Illinois Institute of Technology learn how to reduce engine noise by as much as 50 percent.

Wilson P. Green, professor of mechanical engineering at the college, has designed a double-walled engine noise test room where he can make accurate sound measurement. Believed to be the only such room in existence, it is built on a four-inch platform of soft rubber and lined with a six-inch thickness of fireproof fiberglass.

"We measure the loudest part first, usually the exhaust, reduce it, and then go on to the next loudest," Green explained. "Every gear, piston, and other moving part is carefully checked and muffled. To measure some specific component, such as exhaust noise, engines are placed outside the room with the exhaust piped into the cell through sound-insulated ports. Only the exhaust noise is heard within the room."

Green's noisy patients have ranged from a 20-lb. 1-hp. lawn mower to a 200,000-lb., 2,000-hp. diesel. A combina-

tion of camera, magnetic recorder, and sound analyzer chart the over-all noise; and the engine is then stripped so that each mechanical part, operating separately, can be studied for noise reduction.

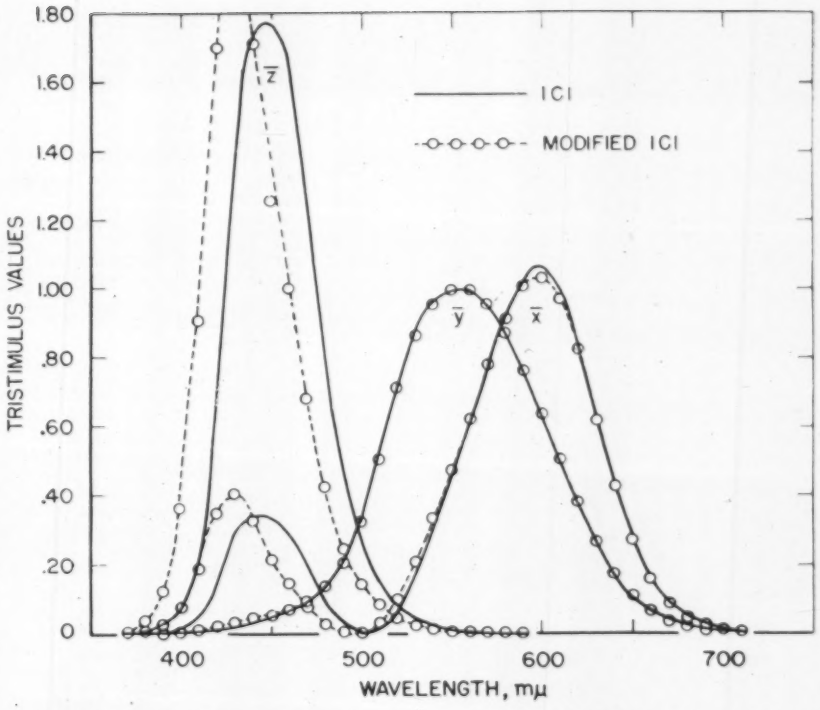
ICI Standard Observer *for* Colorimetry

WASHINGTON, D.C.—Recent work at the National Bureau of Standards indicates that the "ICI Standard Observer," that is, the fundamental data on color mixture that have since 1931 been accepted internationally for interpreting colorimetric measurements, may need to be revised. This work corroborates findings from three other laboratories in this country, Harvard Medical School, Eastman Kodak Company, and National Lead Company.

Modern colorimetry depends upon decomposing the light entering the eye of the observer; or breaking up this light into its spectral components — as Newton first did with a simple prism. The spectral transmittance of standard filters and the spectral reflectance of opaque color standards are measured by means of the spectrophotometer. Since its recommendation in 1931 by the International Commission on Illumination, the standard way of interpreting such spectrophotometric information has been by way of the body of fundamental data on color mixture known as the 1931 ICI Standard Observer. These data have achieved world-wide acceptance.

Considerable interest was therefore aroused by a report from the Titanium Division of the National Lead Company that the ICI Standard Observer was not adaptable to the colorimetry of titanium-pigment paints. A. E. Jacobsen found that, when the well-known near-white anatase and rutile titanium dioxide pigments were incorporated in a paint vehicle, they yielded colors that could be distinguished by eye. However, spectrophotometric data reduced by means of the ICI Standard Observer indicated that the colors were the same. He suggested that the ICI Standard Observer weighs too lightly the spectral region below 430 millimicrons.

As the first step in a study of the phenomenon by Dr. Deane B. Judd of the Bureau's photometry and colorimetry laboratory, a pair of these titanium-pigment paints was examined by seven observers. Four of the seven corroborated Jacobsen's conclusion; three agreed closely with the SO. A modification of the SO was then derived, based upon the spectral luminosity determinations of Gibson and Tyndall at the National Bureau of Standards and of Wald at the Harvard Medical School. The modified observer was shown to account largely for the observations of the group of four observers that disagreed with the SO. Since this work, the Gibson-Tyndall-Wald data on spectral luminosity have had striking corroboration by Weaver of Eastman Kodak; his results likewise indicate the standard luminosity function to be too low in the short-wave extreme of the spectrum.



Tristimulus values of the spectrum according to the ICI Standard Observer compared with the modified observer devised at the National Bureau of Standards. These curves give for each part of the spectrum the amounts of the red (X), green (Y), and blue (Z) primaries required to duplicate the color. For example, the color of the spectrum at 600 millimicrons is duplicated by about 1.05 units of the red primary, about 0.70 units of the green primary, and practically none of the blue. The (Y)-function is the standard luminosity function. The shift of emphasis in the modified functions toward the short-wave extreme of the spectrum is clearly shown.

WHEN A FELLER NEEDS CONTROL

By Phil Putnam

I KNOW THIS FLOWMETER IS OFF! I'VE GOT THAT VALVE OPEN EXACTLY 2½ TURNS AND THE METER SHOULD READ 2500 GPM!
LOOK BUD! THIS VALVE HAS MORE PLAY IN IT THAN THAT BLONDE YOU WERE OUT WITH LAST NIGHT! THAT'S WHY WE PUT FLOWMETERS IN — TO TELL US WHAT IS REALLY GOIN' THROUGH TH' LINE.
IDEA BY:
I.K. GOULD
LONGVIEW FIBRE CO
LONGVIEW, WASH.

Instruments pays $5.00 for each idea used. Sender's name and company affiliation will be acknowledged in the cartoon unless we are specifically requested not to do so. Address Cartoon Dep't, *Instruments*, 921 Ridge Ave., Pittsburgh 12, Pa.

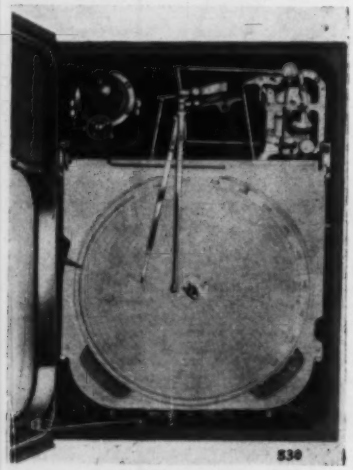
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control — in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 1071

Air-operated Controllers

New "Series 500" air-operated control instruments for temperature, pressure, flow, liquid level, humidity, and pH have calibrated control actions. Reset rate, derivative time, and proportional band adjustments are calibrated and reproducible. Controllers have only

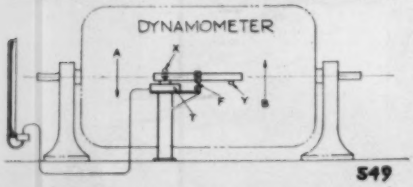


one service adjustment; can be completely disassembled and, after being reassembled with replacement parts, only one adjustment is required to put system in exact calibration. All reset controllers are equipped with reset action stops. New instruments are offered in five types of control action: on-off, proportional, reset, derivative, and reset plus derivative; are readily convertible from one type to another.—*The Bristol Company, Waterbury, Conn.*

Mention No. 1101 when filling out card.

Force-measurement Unit for Dynamometer

New "Uni-Beam" unit will measure force applied in opposite directions, such as dynamometer applications, without use of knife edge bearings or reversing linkage with an accuracy of 0.1 percent. Unit can be easily installed



on almost any type of force-producing machine, either as a replacement of worn or unsatisfactory measuring devices in the field, or on new equipment installations. Sketch illustrates basic action as applied to a dynamometer. In rotation direction A, load is applied at X on measuring unit T. In rotation direction B, load is applied at Y through tension fulcrum F to T. Unit design and operation permits use of remote indicating gages, recording devices, multirange indicators.—*Link Engineering Co., 13845 Elmira Avenue, Detroit 27, Mich.*

Mention No. 1102 when filling out card.

Sulphur-compounds Recorder

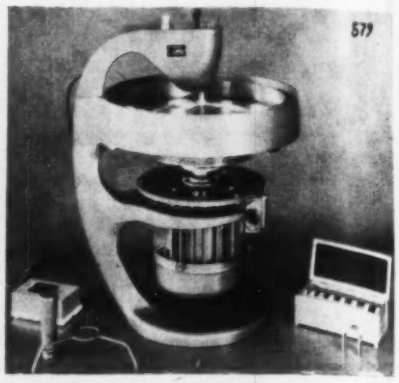
New "Model 26-102 Titrilog," for continuously recording concentration of oxidizable sulphur compounds, in concentrations as low as 0.1 ppm, in a gas stream or atmosphere, utilizes principle of continuous reaction between electrolytically generated bromine and reactive compounds to a potentiometric end point. Rate of bromine generated is automatically controlled to equalize it

to rate of absorption of reactive gas. Generating current, therefore, is a function of sulphur compound concentration. Fluid absorbers permit selective recordings of compounds of specific interest. There are three in standard model and they may be set to operate automatically on any desired sequence. Response to concentration changes is such that maximum titration levels are reached in 20 seconds. Instrument is extremely sensitive, yet its features include adjustments permitting titration of sulphur compounds over a wide range of concentration. Accuracy of quantitative measurement varies with different compounds titrated. However, if calibrated with compounds of interest, accuracies well within 5 percent are obtainable. Operation is on 60-cycle, 115-volt power, requiring approx. 6 amps.—*Consolidated Engineering Corp., Pasadena 4, Calif.*

Mention No. 1103 when filling out card.

Centrifugal-type Dust Classifier

New Centrifugal Dust Classifier for grain size analysis makes it possible to accurately grade dust particles below 60 microns without influence of personal equation. Operation: dust is introduced through a rotary symmetrical slot into a spiral-shaped air current,



flowing towards its center. In order to gain a gentle treatment of the material and a practically frictionless air current in decisive zone of sifting space, the whole sifting chamber is caused to rotate. One part of the dust will here be accelerated by centrifugal force against periphery; and the other carried by air current towards center. Fraction sifted away is collected on stop flange of rotor and is easily removed for microscopic examination. Apparatus is empirically calibrated and grain size limits are easily altered. Unskilled nontechnical operators are preferably used. No difficult measurements or calculations are needed. A complete classification into eight fractions takes less than two hours.—Manufactured by *AB Enkopings Verkstader, Sweden;* temporarily distributed by *Sandvik Saw & Tool Corp., 47 Warren St., New York 7, N. Y.*

Mention No. 1104 when filling out card.

Temperature Test Chamber

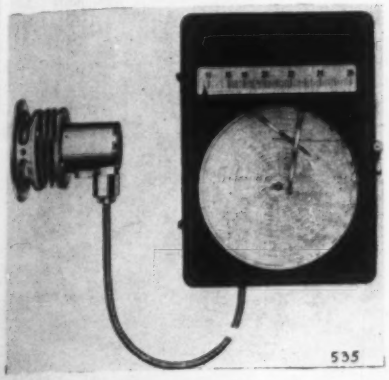
New "Model TC-1" temperature test chamber consists of a sealed inner chamber and outer cabinet of welded dual construction. Cooling is carried out by dry ice; heating by a strip heater. Forced air circulation takes place at all times. Thermostat control, balancing heat against dry-ice evaporation,

maintains any temperature between -65 F. and 275 F. Chamber accepts a load volume of 600 cubic inches and a weight capacity of approximately 10 lbs. Weight is 63 lbs. and dimensions are 16.5 x 12 in.—*Statham Laboratories, Inc.*, 9328 *Santa Monica Blvd., Beverly Hills, Calif.*

Mention No. 1105 when filling out card.

Radiation Pyrometer

New "Pyrovisor" radiation pyrometer is designed for indicating, recording, or controlling temperatures up to 4000



F. in furnaces and kilns. Temperature-sensitive head is mounted on outside of furnace or kilns, away from hot zone, and picks up radiant energy emitted from surface of object under measurement. Extremely rapid response is claimed as its outstanding feature: 99 percent response to a temperature change within one second.—*The Bristol Company, Waterbury* 20, *Conn.*

Mention No. 1106 when filling out card.

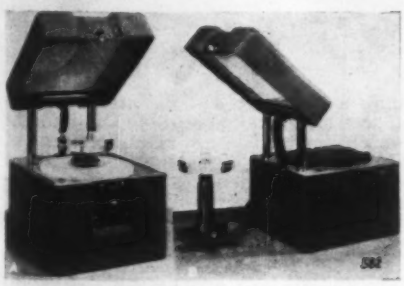
Conductivity Bridge for Hydrochloric Acid

New "Model RD-20C Solu-Bridge" covers range 1-20 percent HCl and contains a manual temperature compensator of range 64-190 F. Bridge is line-operated and incorporates a 3000-cps. bridge source oscillator.—*Industrial Instruments, Inc.*, 17 *Pollock Ave., Jersey City* 5, *N. J.*

Mention No. 1107 when filling out card.

Monochromatic Light and Optical Flat

New "Lapmaster" optical flats and monochromatic lights permit checking flatness accuracy to less than one light band (0.0000116 in.). "Lapmaster" Monochromatic Light provides better than 25 foot-candle-power illumination on checking surface. Its helium-filled tubular-light is recessed into cover and diffuses light through a flashed



opal diffusing glass. Light transmitted is a strong, near one-color light of 11.6 microinches per dark interference band. Optical flats are of natural quartz, highly transparent, abrasion resistant and will withstand thermal shock. Flats of 0.1 and 0.2 light-band accuracy (1.16 and 2.32 microinches are standard. Available sizes up to 6-in. diam.—*Crane Packing Co.*, 1800 *Cuyler Ave., Chicago, Ill.*

Mention No. 1108 when filling out card.

Multiple-point Pyrometer Indicator

New "Model 10252" multi-point pyrometer and quick-coupling-connector panel assembly is designed for indicating temperatures from one to six thermocouple locations at operating ranges from 75 to 400 F., 1000 F., 1600 F. and 2300 F., and minus 300 to plus 300 F. or equivalent Centigrade scales. Calibrated for iron-Constantan, Chromel-Alumel or copper-Constantan, new indicator assembly is automatically compensated for cold-junction temperature changes and instrument tempera-

ture-resistance coefficient. Scale is 3.17 inches long and movement is housed in a removable Bakelite case. Polarized quick-coupling plug connects pyrometer to any of six thermocouple jacks. All plugs and jacks are of thermocouple materials, thus eliminating errors produced by connections made of different and unmatched elements. Connector panel is 5.75 in. wide by 9 in. high and can be mounted flush on larger instrument panel boards. —*Thermo Electric Co., Inc., Fair Lawn, N. J.*

Mention No. 1109 when filling out card.

Buffer Solutions for Calibrating pH Instruments

New buffer solutions for calibrating any pH instrument have nominal pH values of 4, 7, and 9; actual, 4.01, 6.86, and 9.16 at 25 C. Solutions are supplied in 1-pt. unbreakable non-contaminating re-usable polyethylene bottles on which are printed pH-temperature calibrations from 0 to 60 C. Buffers are made, and checked after bottling, to National Bureau of Standards specifications.—*Leeds & Northrup Co.*, 4934 *Stenton Avenue, Philadelphia* 44, *Pa.*

Mention No. 1110 when filling out card.

Hand Refractometer

New pocket-size refractometer, designed especially for fruit and vegetable growers and processors, is designed to read total dissolved solids content directly to one-tenth of one percent with either transmitted or reflected light. On-the-spot inspection to determine quality of fruits and vegetables during ripening stage or juices and beverages before or after canning or bottling may be made over a range of 0 to 25 percent. A built-in temperature correction thermometer, graduated

in percentage of total dissolved solids, obviates referring to correction tables when temperatures other than standard 20 C. are present.—*Bausch & Lomb Optical Co.*, 635 *St. Paul St., Rochester* 2, *N. Y.*

Mention No. 1111 when filling out card.

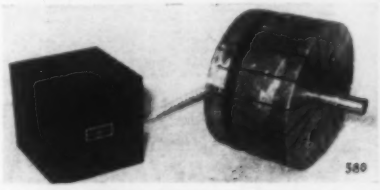
Instrumentation Motor

New "Type 6T60" laboratory variable-speed motor and control has 0.05-hp. d-c. shunt wound gear-head-style motor. Control uses five thyratrons in cascade to operate motor at 300-4000 rpm. with a reduction of 20:1 to gear shaft. Motor is reversible and can be run continuously. At 300-1800 rpm., torque is constant, and from 1800-4000 rpm., hp. is constant. For 115-volt 60 cps. single-phase.—*Gerald K. Heller Co.*, 1530 *Ridgely St., Baltimore* 30, *Md.*

Mention No. 1112 when filling out card.

Stroke-type Electric Power Unit

New "Electrothrust" power units are capable of applying pressures up to several tons for operations requiring



pressure, impact, or impact followed by pressure, with strokes from a fraction of an inch to several inches in length. Types of work for which units are suited fall into two categories: (1) work requiring an increasing force, up to tons, over a fraction of an inch and with maximum at end of this short stroke; (2) a thrust of 100 lbs. or less exerted over strokes up to about 8

inches. Of cylindrical cast electrical-steel construction, units operate from any a-c. lighting circuit. Model illustrated is 9 inches in diameter, 5 in. long and develops a maximum pressure of 6,000 pounds.—*Black & Webster, Inc., Needham 92, Mass.*

Mention No. 1113 when filling out card.

Portable Electric Tachometer and Cutmeter

New "M1200-F" electric tachometer and cutmeter assures accuracy of better than one-half percent of full-scale value in measuring either surface speeds or shaft speeds over ranges of 0 to 5,000 fpm. or 0 to 25,000 rpm. Standard cable connecting generator and indicator

may be lengthened to 500 feet. Laboratory type indicator has 4 overlapping speed ranges. Two styles of driving points, an extension shaft, and cutmeter wheel are supplied.—*Electric Tachometer Corp., 2218 Vine St., Philadelphia 3, Penna.*

Mention No. 1114 when filling out card.

Pressure Controller

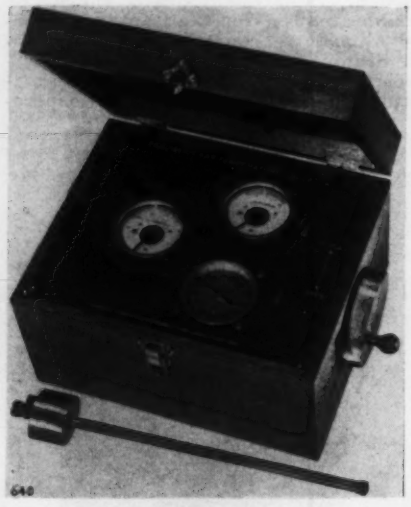
New "No. 1500 Pilot" is a pressure controller for the following types of service: (1) pressure reducing, (2) back pressure, (3) pressure relief, (4) vacuum, (5) vacuum relief, (6) pump governor regulation and (7) boiler fuel governor. Increased accuracy is reportedly due to use of a sensitive helix spring rather than conventional "C" gage spring. For temperature control,

spring may be replaced by a thermal element. Other features include: indicator and calibrated scale showing set pressure, adjustment of set pressure and throttling range without use of tools, change from direct to reverse action without disturbing pressure connections and without tools. Mounting bracket allows installation directly over valve being controlled or remotely, either surface-mounted or flush-panel mounted.—*MacAlear Mfg. Co., 1901 S. Western Ave., Chicago 8, Ill.*

Mention No. 1115 when filling out card.

High-gas-temperature Indicator

New "Model 263 Gas Temperature Indicator" is improved version of "Unit 263" fully described, with three illustrations, in our May 1948 issue, page 418. It permits measuring gas temperatures to more than 5000 F. A small sample of gases is obtained by means of a water-cooled stainless-steel probe (which may be manipulated to obtain a temperature traverse of gas stream). Sample passes through a

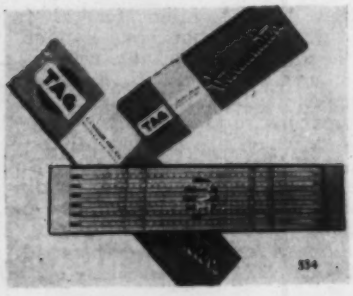


small iridium orifice, is cooled and passes through a second orifice and a manually-operated pressure-reducing valve to atmosphere. By adjustment, pressure drop across iridium orifice will be a linear function of absolute temperature of gases being measured. A differential-pressure gage connected across iridium orifice then indicates this temperature.—*West Coast Div., Fairchild Camera & Instrument Corp., 53 W. Union St., Pasadena, Calif.*

Mention No. 1116 when filling out card.

Thermometer Package

New package for glass thermometers is designed to reduce breakage, simplify inspection and testing, and speed identification of contents. All maker's A.S.T.M. and Standard Grade ther-

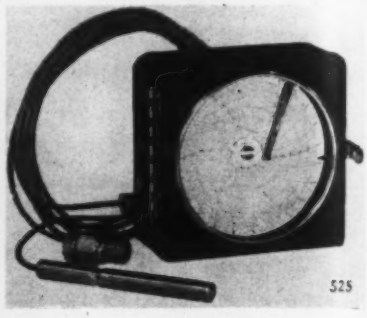


mometers are now shipped in these boxes, where they are held in place by cardboard spacers. All are instantly visible when box is opened, can quickly be removed after cardboard insert is lifted free of box. New packaging also permits quick identification of contents when thermometers are stocked on shelves.—*C. J. Tagliabue Corporation (N. J.), 614 Frelinghuysen Avenue, Newark 5, N. J.*

Mention No. 1117 when filling out card.

Miniature Recorders

New line of recorders for temperature, pressure, and electric operation are available in two series: "Series I" dimensions 5.25 x 5.25 x 2.25 inches,

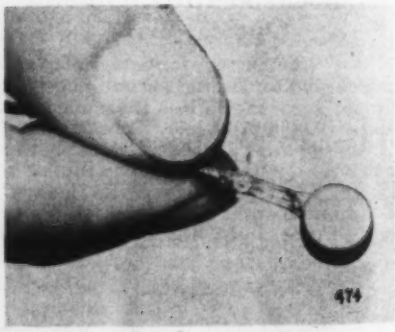


weight 2 lbs., equipped with 24-hour spring-wound clocks or synchronous motors for certain types. "Series II" dimensions 6.25 x 5.25 x 3.5 inches, weight 3.5 lbs., equipped with 7-day clock or synchronous motor. Five types offer flexibility in temperature measurements between —50 and 600 F., in pressure measurements from vacuum to 600 psi, and in electrical operations recording for which a resistance of less than 1 ohm is introduced by recorder coil in series operation. Combination temperature and electric-operation two-pen recorder is also available.—*The Dickson Co., 7420 Woodlawn Ave., Chicago 19, Ill.*

Mention No. 1118 when filling out card.

Vibration Frequency Pick-up

New "Vibratab" is a vibration frequency pick-up the size of an aspirin tablet (0.31 inch) and weighing less



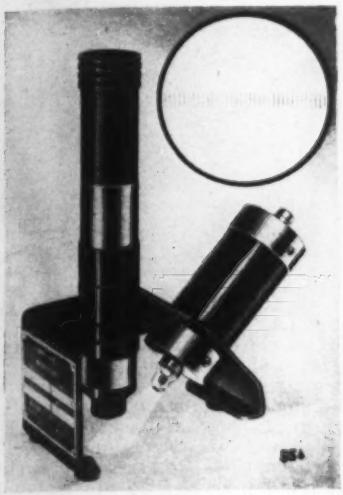
than a gram. It will fit into restricted spaces hitherto inaccessible and its light weight permits accurate "testing of highly sensitive test structures" without danger of influencing vibration characteristics. It has a life expectancy of 100 to 300 hours and will respond to acceleration frequencies from 3 to over 2000 cps. Makers of "Vibratab" announce that they also design and manu-

facture automatic machines for reading and counting graphical data from graphs, film or tape records, which will accurately read and record, at a great saving in time, oscillogram records produced by "Vibratab."—*Telecomputing Corporation*, 2901 *Hollywood Way, Burbank, Calif.*

Mention No. 1119 when filling out card.

Industrial Microscope

New "Model No. 232" industrial microscope has built-in illumination and magnification of either 20 or 40. A reticle permits direct measurements with divisions of 0.004 and 0.002 in. Eye point is over 1 in. above eyepiece,



enabling operator to work when wearing glasses so as to provide corrected vision for all examinations. Focusing is by means of a friction sliding tube.—*Clarkstan Corp.*, 11927 *W. Pico Blvd., Los Angeles* 34, *Calif.*

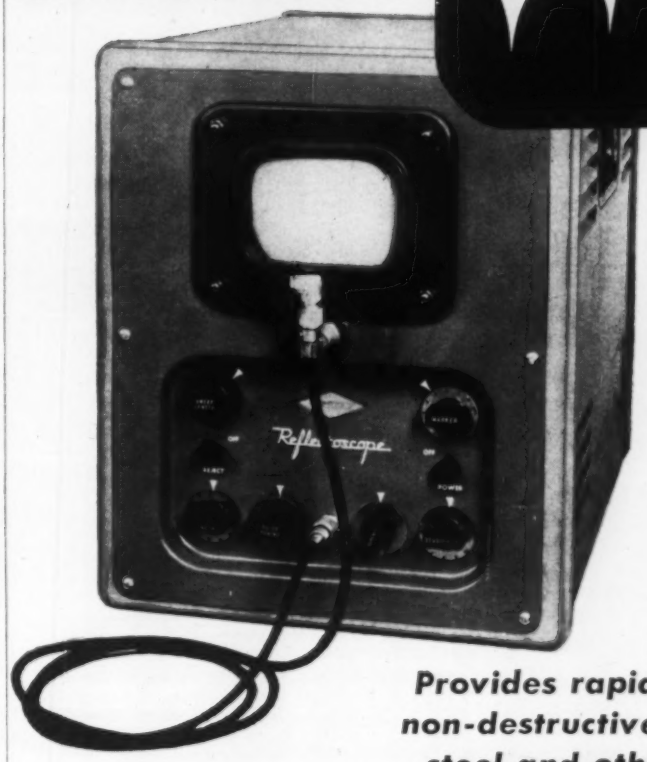
Mention No. 1120 when filling out card.

Instrument Parts Cleaning Machine

New automatic small-parts cleaning machine is furnished with a complete array of baskets, dividers and basket inserts, as well as with a quantity of L & R cleaning and rinsing solutions, so that equipment can be put to work immediately upon receipt. To operate, place parts in most suitable basket (or subdivision in basket), snap basket on motor shaft, and press starter button. Action is fully automatic: through cleaner in first jar, through

Improved quality control of metals at **LOWER COST**

SPERRY ULTRASONIC REFLECTOSCOPE



Reflectoscope, Type UR, Style 50E351.

Provides rapid accurate non-destructive testing of steel and other metals

Metals tested by the Reflectoscope are preferred by users who cannot afford lost machine and man hours. The expense of lost work on faulty metals and possibility of service failures are minimized when potentially harmful defects are located before fabricating or machining.

The cost per test is low because it is instantaneous. The operator touches the quartz-crystal Searching Unit to the surface and immediately "sees" through the metal. Discontinuities are revealed on the Reflectoscope screen and are located accurately. For full details write for new Bulletin 50-105.

- CONTROLLED SENSITIVITY —can be adjusted to meet quality control standards.
- PORTABLE UNIT — can be set-up quickly by one man.
- TESTS PARTS "IN PLACE" —locates fatigue cracks in shafts, rolls, axles and other stressed parts. Operates on 100-130 volt, 60 cycle current.

SPERRY REFLECTOGAGE. Measures thickness of metals and other materials by resonance at ultrasonic frequencies. Accuracy within 2%. Full details in Bulletin 3700.

SPERRY PRODUCTS, INC.
DANBURY, CONN.

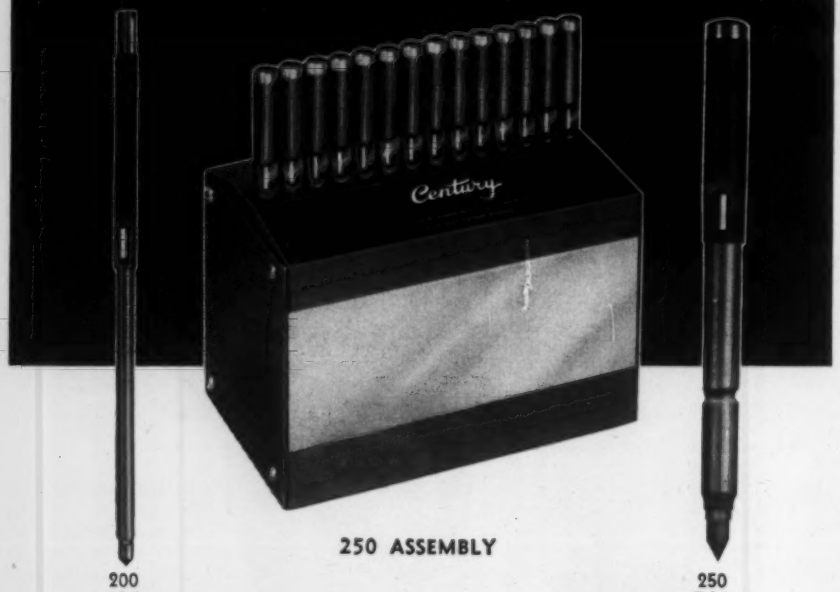
Sperry

SP-150

Century RECORDING GALVANOMETERS

are engineered for

ACCURACY — VERSATILITY — STABILITY



250 ASSEMBLY

200 SERIES

250 SERIES

The accuracy, stability and versatility obtainable in CENTURY Galvanometers are the factors which insure maximum performance in photographically recorded measurements. They are available with sensitives as high as 4 microamperes per inch with natural frequencies from 30 cps to 5000 cps. These elements may be used with all types of measuring devices, with or without amplification and, in most instances, are immediately adaptable for use in any type or make of photographic recording oscillographs. The small, compact size of these galvanometers permits use of more channels where space requirements are limited, without sacrificing efficiency. The use of the plug-in-type mounting system allows instant changing or interchanging of elements for multi-purpose recording without changing wired connections.

CENTURY Galvanometers are so constructed that they will withstand shocks up to 300 g's, even in the lower frequency units.

Other desirable features of CENTURY Galvanometers include:

LINEARITY: ±2% for ±25° rotation of image at 15½" optical distance.

ZERO DRIFT: ±.0004"/°F. at 15½".

SPOT ADJUSTMENT: Horizontal spot adjustment is made by rotating the entire Galvanometer within the assembly thus no torsional strain is placed on the suspension. Therefore, damage to the suspension is impossible during spot adjustment.

POLE PIECES: Flush with tubular case which rotate with the coil when horizontal spot adjustment is made, thus maintaining the flux path across the coil at the correct angle.

SIZE: 2.9375 x .230 Dia. for 250 (G-14) Series, and 3.375 x .127 Dia. for 200 Series.

Manufactured under Century Patent 2439576, also licensed by Kannestine Laboratories Patent 2149442

For additional information write

Century GEOPHYSICAL CORPORATION
TULSA, OKLAHOMA

216 No. 12th Street
Philadelphia 7, Pa.

EXPORT:
149 Broadway, New York

rinses in second and third jars and in drying chamber which is fourth and last stop. Cleaning cycle duration is 12 minutes.—*L & R Mfg. Co., 577 Elm St., Arlington, N. J.*

Mention No. 1121 when filling out card.

Strain Indicator

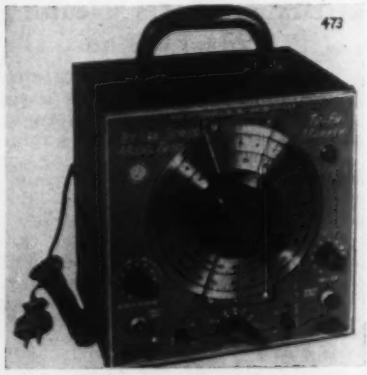
New self-balancing dial-type strain indicator for use in stress analysis with Maker's "SR-4" bonded-resistance-wire strain-gages has a dial scale calibrated to read directly in microinches per inch for standard gages (gage factors from

1.90 to 2.20). Adjustments for gage factor and for zero setting are provided above dial inside case. Indicator can be used either with a single strain gage or with multi-point switching and balancing units; is available with one, two, or all three ranges: 0 to 2000, 0 to 5000, and 0 to 10,000 microinches of strain per inch of strained surface. Scales other than that illustrated are available.—*Baldwin Locomotive Works, Philadelphia* 42, *Penna.*

Mention No. 1122 when filling out card.

TV Sweep Marker

New "Model TV 50," designed primarily for use in marking television sweep generators, has a large dial cali-



brated from 5 Mc. to 250 Mc. in four bands, and a planetary drive for fine-control tuning. A self-contained crystal oscillator circuit is included so that simultaneous marking can be utilized or it can be used alone with variable frequency marker turned off. A phasing control circuit enables adequate alteration of dual trace found in sweep generators of electro-mechanical type. Oscillator design is such that any crystal from 1 Mc. up may be used in crystal socket (conveniently located in front of panel). This socket accommodates any generally-available crystals

mounted in FT243 holders. An internal mixing circuit provides for receiving output of any sweep generator so that output leads carry both sweep frequency and marker frequency. Size 9 x 9 x 7 in. Weight 11 lbs. Tube complement 12AT7-6C4-VR105-6X5GT/G. Operates on 105-130 volts, 60 cycles.—*Radio City Products Co., 152 W. 25th Street, New York 1, N. Y.*

Mention No. 1123 when filling out card.

High-gain Low-frequency Amplifier

New "Model 33" is an extremely-high-gain narrow-band amplifier designed for operation at or near a frequency of 10 cps., featuring complete a-c. operations, shock-proof mount-

ing, and minimization of effects of electrical pick-up. "Model 33A" is intended for use with photocells, thermistors, or other high-impedance devices; "Model 33B" is mainly intended for amplifying output of low-impedance thermocouples, bolometers, etc. Both are also useful as general-purpose laboratory instruments wherever low-level 10-cps. voltage or current measurements are required. A tuning control permits adjusting actual frequency over a range of approx. 2 cps. so that maximum response can be obtained when signal under measurement is between 8 and 12 cps. (approx.). Amplification is about 6×10^6 to rectifier bridge in output in "33A," and about 6×10^8 (from a 20-ohm circuit) in "33B." A calibrated attenuator permits gain to be changed in convenient steps by factors up to 1000.—*Electro-Mechanical Research, Inc., Ridgefield, Conn.*

Mention No. 1124 when filling out card.

A-c. Voltage Supply

New "No. 6-054 Electronic Power Supply" is a voltage-regulating device designed for use with photometric in-

struments employing low-voltage lamps, or other devices requiring a perfectly stabilized source of low-voltage power. It delivers regulated alternating voltage at 6.2, 8.5 and 10.0 volts; may be connected to a.c. of any voltage between 95 and 135 and any frequency

Century MODEL 406

RECORDING OSCILLOGRAPH

FOR

VIBRATION — TEMPERATURE

STRESS — STRAIN ANALYSIS

where any or all of the above information is an important factor.

FEATURES

1. 12—50 individual channel recording.
2. Continuous recording up to 200' without jamming
3. Instantaneous changes of recording speeds up to 50" per second with automatic adjustment of lamp intensity.
4. Timing System — Discharge lamp controlled by temperature compensated tuning fork providing sharp .01 second with heavier .1 second timing lines. Conversion to .1 second lines only, by switching.
5. Independent optical system provides constant view of traces with optimum light intensity at all times.
6. Recording lamp under constant surveillance of external condition indicator lamps.
7. Galvanometers — with optional range of frequencies and sensitivities.
8. Electrical — Available for operation from option of 12 or 24 volts D.C., or 110 volts A.C.

OPTIONAL FEATURES

1. Trace identification by means of light interruption.
2. Trace scanning for observation of steady state phenomena.
3. Remote control unit.
4. Automatic record numbering system.
5. Automatic record length control.
6. Visual paper footage indicator.

For additional information write

Century GEOPHYSICAL CORPORATION

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EXPORT:
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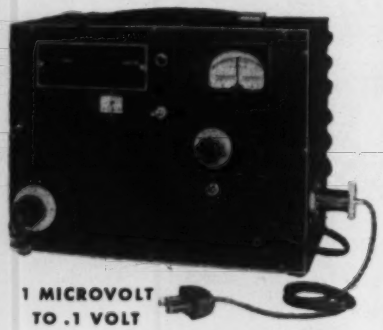
FM SIGNAL GENERATORS

MODEL 78-FM

86 Mc.—108 Mc.



DEVIATION: Directly calibrated dial. Two ranges, 0 to 30 kc., 0 to 300 kc. Internal 400 cycle oscillator. Can also be modulated from external source.

DIMENSIONS: 10"x13"x7". Weight 20 lbs.

POWER SUPPLY: 117 volts, 50-60 cycles. 36 watts.

• SPECIAL GENERATORS

One-band Model 78-FM generators, with a tuning ratio of approximately 1.2 to 1, are available for use within the limits of 30 to 165 megacycles.

MODEL M-275

I. F. CONVERTER

For Use With Model 78-FM.

CARRIER FREQUENCIES: 4.5 Mc.; 10.7 Mc.; 21.7 Mc. (Provision for one extra frequency).

OUTPUT: When used with Model 78-FM the output voltage is variable from 10 microvolts to 1 volt.

POWER SUPPLY: 117 volts, 50-60 cycles, 45 watts.

MEASUREMENTS CORPORATION

BOONTON NEW JERSEY

between 55 and 65 cps. Its output voltage will remain stable to within 0.2 percent even though both input voltage and input frequency vary over these limits. If input voltage range is restricted to 100-130 volts, it may also be used at frequencies of 49.5 to 50.5 cps. It is equipped with a three-position switch for selection of output voltage and is furnished with a 6-ft. line cord. Output voltage is brought out through a 6-ft. instrument cord terminated in a plug designed for maker's photometric instruments (special adaptor available to permit use with other devices or with instruments not equipped with Coleman receptacle). — *Coleman Instruments, Inc. Maywood, Ill.*

Mention No. 1125 when filling out card.

Split-core Volt-ammeter

New pocket-size "Amprobe" measures current without interrupting service; is said to represent "a complete deviation in split-core volt-ammeter design". A plastic finger trigger opens jaws and clamps around conductor to measure

current; to measure voltage a pair of test leads are inserted into front-mounted pin-jacks and connected to line. Dimensions: length 7.12 in., width 2.56 in., thickness 1.12 in. Weight 12 oz. "Amprobe" is available in two models, each with seven ranges. "Model A-5" 6.5/13/26/65/130 amps. and 130/260 volts; "Model A-6" 10/25/50/198/250 amps. and 150/600 volts. Scale length 2.47 in. No metal parts come in contact with operator. Jaws are insulated with 0.06-in. cover of molded nylon, will handle conductors up to 1.12 inches in diameter. Trigger and seven-position selector switch are operable by hand holding instrument. Accuracy plus or minus 3 percent of full scale.—*Pyramid Instrument Co., 49 Howard St., New York 13, N. Y.*

Mention No. 1126 when filling out card.

Wide-band Amplifier for Microwave Pulse Amplification

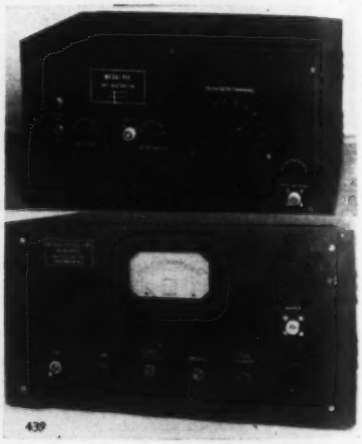
New "460A" wide-band amplifier for amplification of microwave pulses is designed to facilitate measurements necessary in TV, UHF, nuclear, oscilloscope and general laboratory work, up to 200 Mc. It is said to offer true amplification without objectionable ringing or overshoot. Pulse rise time is 0.003 microsecond and a gain of 20 db is

provided. As many as five instruments can be cascaded to provide additional gain. It is also designed for use with maker's "410A" VTVM and in this connection will increase voltmeter sensitivity ten times at frequencies up to 200 Mc. Since new instrument gives optimum performance through impedance of 200 ohms, maker has designed a 200-ohm coaxial system of connectors and cables to be used with it: leads with fittings, panel jacks, plugs and cables, adapters, etc. — *Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.*

Mention No. 1127 when filling out card.

TV Test Instruments

Two new television test instruments are announced: (1) "Mega-Pix" generates accurate picture and sound carriers in each of the twelve TV channels selected by a front panel switch. Sound carriers are frequency modulated by an internally generated tone. Frequency deviation is adjustable by front panel control. Picture carrier can be modulated by RMA video signal either from



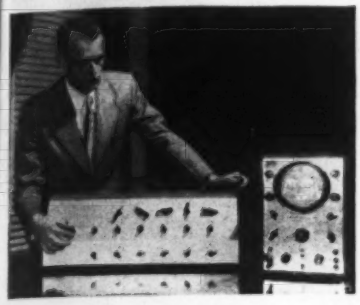
external generator from a receiver tuned to a transmitter. Modulation depth adjustable by front panel control. Picture modulation double side band. (2) "Mega-Node Sr." is a calibrated random noise generator useful in determining noise figure (db above ideal) of receivers or amplifiers in UHF and microwave frequency ranges. The noise figure may be read directly in linear db. Voltage standing wave ratio at coaxial output connector has been kept low over entire frequency range. No tuning or adjustment is necessary when used within specified frequency range. Corrections at upper frequency, made necessary by noise diode transit time, supplied with each instrument.—*Kay Electric Co., Pine Brook, N. J.*

Mention No. 1128 when filling out card.

Harmonic Generator

New portable harmonic generator, for use in instructing science and engineering students in theories of wave formation, consists of six voltage-generating units mounted on a single shaft and driven by a synchronous motor. Outputs are a fundamental voltage and five harmonic voltages having fre-

encies two, three, four, five, and seven mes that of fundamental voltage. oltages are fed into an oscilloscope hich translates them into images on screen. Virtually any wave-shape eeded in a given engineering problem an be produced, including square aves, saw-tooth waves, Lissajous figres, Doppler effect, wave-shapes across lectrical impedances, resonances of

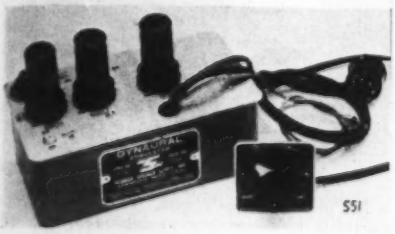


circuit components, etc. Controls on sloping panel enable operator to adjust phase of each harmonic through a range of 0 to 360 degrees. Amplitude adjustments of each of the six voltages may be obtained separately. A switch on each output permits harmonics to be inserted or removed separately from output terminals of generator. Generating units being on one shaft, designed harmonic frequency relation is inherent; drifting, jumping out of synchronism, and other such uncertainties are impossible. — *Special Products Div., General Electric Co., Schenectady 5, N. Y.*

Mention No. 1129 when filling out card.

Dynamic Noise Suppressor

New "Type 111-A Dynaural Converter," designed for use with standard amplifiers, phonographs, and combina-



tions, has a 14-kc. range; is said to minimize needle scratch as well as pops and crackles on plastic records and rumble from turn-table motors.—*Hermon Hosmer Scott, Inc.*, 385 *Putnam Avenue, Cambridge* 39, *Mass.*

Mention No. 1130 when filling out card.

Dual-channel Oscilloscope

New "H-21" dual-channel oscilloscope contains two separate and complete electron guns in a single 5-in. flat-face tube. Each channel has individual controls for intensity, focus, and X, Y, and Z axes. Vertical deflection sensitivity is less than 0.1 volt d.c. per inch. Vertical amplifiers have conductive differential input in the unity attenuator setting, allowing use of push-pull preamplifiers. Vertical and horizontal amplifier outputs are interchangeable, thus allowing connection of more sensitive amplifier to horizontal deflection plates. Triggering is in continuous

Speedy • Accurate

RESISTANCE MEASUREMENTS

. . . with the Rubicon
PORTABLE WHEATSTONE BRIDGE

This convenient instrument combines instant portability with high accuracy and is widely used in laboratory, plant and field. Built for dependable service under hard usage.

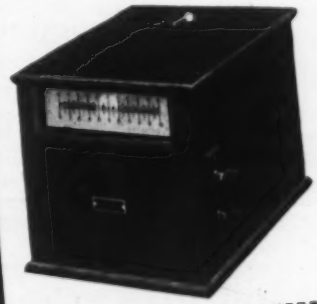
- Wide range: 1 ohm to 10 megohms
- Limit of error: 0.1%
- Built-in battery and galvanometer
- Provision for external battery and galvanometer when required
- Available with Murray and Varley loop circuits
- Compact and rugged

. . . with the Rubicon
PORTABLE KELVIN BRIDGE

For work at very low resistance levels this instrument is the counterpart of the Wheatstone bridge shown above.

- Range: 0.0001 to 10.1 ohms
- Limit of error: 0.25%
- Built-in battery and high sensitivity "Pointerlite" galvanometer
- Provision for external battery and galvanometer when required
- Sturdy and convenient in operation

Wheatstone and Kelvin bridges in a variety of models, together with other resistance measuring instruments, are fully described in Bulletin 100 available on request.



SPOTLIGHT GALVANOMETER

- Sturdy, short period
- Sensitive (up to 0.0006 μA per mm.)
- Multiple-reflection optical system
- For null or deflection measurements

Described in Bulletin 320

OTHER RUBICON INSTRUMENTS

Resistance Standards • Mueller Bridges • Precision Potentiometers • Evelyn Photoelectric Colorimeter for chemical analysis • Automatic Recording Photometric Analyzers for NO and H_2S • Magnetic Permeameters • Magnetic Hardness Testers • Shorted-Turn Coil Testers • Other equipment involving precise measurement of electrical quantities.

RUBICON COMPANY

Electrical Instrument Makers

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COMPLETE DATA on Industrial Thermometers

NEVER BEFORE has complete data on liquid-in-glass INDUSTRIAL THERMOMETERS been put into such an easy-to-use reference guide form.

If you purchase or use thermometers, you'll want your copy in a hurry.

Write for Princo Bulletin "E"

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THERMOMETER & INSTRUMENT CO.

PRINCO

1437 Brandywine Street, Philadelphia 30, Pa.
In Canada: Peacock Brothers Limited

sweeps of 2 cps. to 50 kc; half second to 20 microseconds. Delay after triggering is less than one microsecond. Calibration voltage is continuous and indicated, 0 to 1 volt peak to peak, on a panel voltmeter. Range, up to 100 volts. Weight 65 lbs. Dimensions 14.25 x 16.75 x 21 in.—*Electronic Tube Corp., 1200 E. Mermaid Lane, Chestnut Hill, Philadelphia 18, Pa.*

Mention No. 1131 when filling out card.

Peak Voltmeter Rectifier

New "Type 518P5" rectifier unit is for use with electrostatic voltmeters. Accurate peak voltage readings are assured because of negligible current drain of indicating meter. Readings are independent of frequency and waveform from power frequencies up to low radio frequencies. One rectifier unit may be used with electrostatic voltmeters reading from 100 volts full-scale to 5000 volts full-scale. Readings of either plus or minus peaks are available at the turn of a switch. New unit matches maker's "type 518" electrostatic voltmeters in physical size and terminal arrangements. Another unit, "Type 518P15," is available for measurements up to 15-kv. peaks. New rectifier type peak voltmeters will be useful for measurements on power circuits, transformers, high-voltage pulse measurements including microsecond pulses, peak ignition voltage measurements on automotive equipment, and high-frequency high-voltage measurements. Current drain from source being measured is extremely low in all cases.—*Rawson Electrical Instrument Co., 112 Potter St., Cambridge 42, Mass.*

Mention No. 1132 when filling out card.

Electrical Indicating Instruments

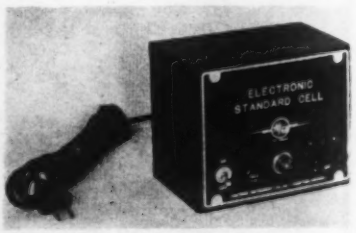
New line of panel instruments of internal-pivot-type construction comprises Types "DO-81" (d.c.), "DO-82" (thermocouple), and "DO-83" (rectifier), in standard 3.5-inch round and square cases with 250-degree scales 4.92 inches long. Except for high-sensitivity microammeters, they are available in all ratings now listed for conventional 3.5-inch instruments with 90-degree scales. Complete line which falls into 2 percent basic accuracy class, is mechanically interchangeable with maker's 3.5-inch round

flange, and rectangular designs. Round design is interchangeable with conventional 3.5-inch round instruments which conform with Mounting Specifications JAN.-I-6. Because of self-shielding characteristics of concentric magnet, no special calibration is required for mounting on steel panels.—*General Electric Co., Shenectady 5, N. Y.*

Mention No. 1133 when filling out card.

Electronic Standard Cell

New electronic cell is available for any specified d-c. output voltage from 0 to 100 and for any load up to 30 ma. Output voltage is constant to better than 0.1 percent and with ripple less than 0.01 percent throughout an input range of 75 to 135 volts a.c. at frequencies from 50 to 400 cps. It is not damaged by momentary short circuits. It can be used either as a reference voltage in bridge or potentiometer circuits or for supplying current continuously as an instrument power supply. Precise output voltages such as 0.10, 1.00 or 100.00 volts d.c., or the usual standard cell voltage of 1.018, can be supplied. Electronic standard cells designed on the same circuit principles for output voltages above 100 volts d.c. for operation on other input voltages, higher current drains, or with non-standard chassis construction are available on special order.—*Hastings Instrument Co., Inc., Box 1275, Hampton, Va.*



Mention No. 1134 when filling out card.

Current Indicators

New "Mini-Amp" indicates load current of motors and other a-c. operated electrical devices. It is less than 2 inches square, with an opening in center. Depending upon number of turns through center, a neon indicator lamp glows at minimum amperage flow.

$500 Prize Contest
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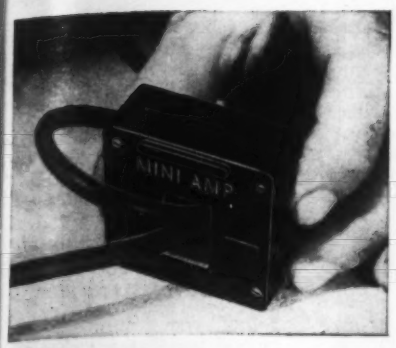
See announcement on page 1009

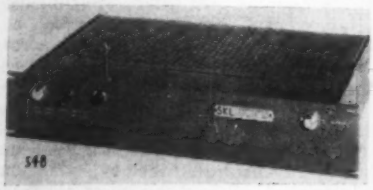


Available in different ampere ratings, new devices can serve to check motors, etc., for overloads. Accuracy is better than 5 percent, does not depend upon insulation, line voltage or manner in which wire turns are made.—*Industrial Devices, Inc., Edgewater, N. J.*

Mention No. 1135 when filling out card.

Wide-band Amplifier

New "Model 202P Wide-Band Chain Amplifier" with regulated power supply has a gain of 20 db and a band width of 200 Mc. Regulated power supply, incorporating a new circuit, insures constant gain within plus or minus 1 percent for line voltage variations of

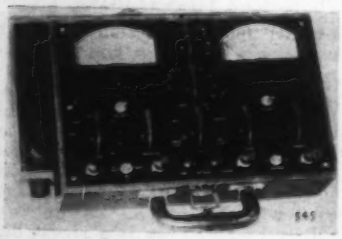


plus or minus 10 percent. Amplifier has a transmission characteristic of plus or minus 1·5 db from 100 kc. to 200 Mc., an impedance of 200 ohms, a substantially linear phase shift, a rise time of 0.003 microseconds, stabilized gain and a maximum undistorted output voltage of 4 volts. Mounted in a light-weight aluminum chassis, "Model 202P" is 3.5 x 19 x 11 in. and can be rack or table mounted. —*Spencer-Kennedy Laboratories, Inc., Dep't I,* 186 *Massachusetts Avenue, Cambridge* 39, *Mass.*

Mention No. 1136 when filling out card.

Multi-range Electrical Tester for Corrosion, etc., Studies

New small model of "Multi-Combination Meter," designed specifically for electrolysis and corrosion investigations and cathodic protection testing in both field and laboratory, is available with either of two sets of instruments: "Model B-2" is a small instrument for use by corrosion engineers and their assistants where high accuracy and other features of "Model 5" are not required;



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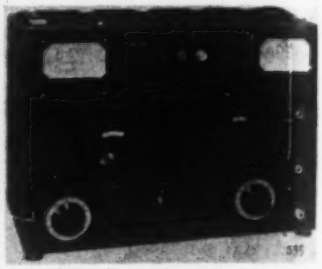
"Model B-1" is for use by junior engineers and cathodic-protection operating personnel who require a more rugged instrument. It is light-weight (about 13 lbs.) and housed in a 9 x 12 x 16 in. walnut case. Standard flashlight dry cells are used and can be replaced without soldering.—*M. C. Miller, 1142 Emerson Avenue, West Englewood, N. J.*

Mention No. 1137 when filling out card.

Signal Generator

New "Model 82" was designed to provide in one signal generator a continuously-variable signal source for most measurements at audio, supersonic and radio frequencies. Two oscillators are employed to cover frequency range



Low-frequency oscillator, continuously variable from 20 cps. to 200 kc., has metered output from 0 to 50 volts across a resistance of 7500 ohms. A r-f. oscillator covering range from 80 kc. to 50 Mc. provides output from 0.1 microvolt to 1 volt and may be modulated with low-frequency oscillator. An improved mutual inductance type attenuator insures a higher degree of accuracy than may be obtained with resistor attenuator or mutual inductance type attenuator of earlier design. Instrument has individually-calibrated direct-reading dials for each range.—*Measurements Corporation, Boonton, N. J.*

Mention No. 1138 when filling out card.

D-c. Power Supply

New d-c. power supply with 5 percent regulation and 0.25 percent ripple is designed to operate continuously with

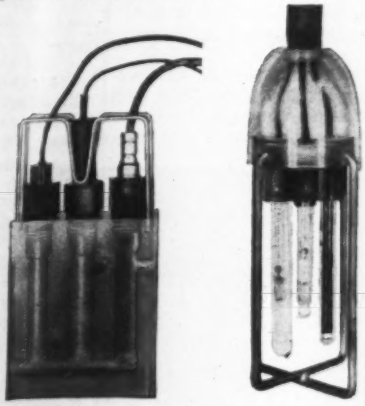
no more than a 10 F. temperature rise when furnishing 400 ma. at 110 volts; is designed to fit on a standard relay rack panel.—*Industrial Electronics Co., Hanover, Mass.*

Mention No. 1139 when filling out card.

pH Electrodes

New pH electrode assemblies for use with maker's recorders and controllers feature waterproof design. One assembly is for continuous sampling lines; the other for immersion in open channels and tanks. Sampling line assembly has low capacity which permits a high flow rate and minimizes coating of electrodes by suspended material. Operating pressure can be up to 15 psi. Body of assembly is a single block

of clear plastic. Inlet and outlet connections fit standard quarter-in. pipe. Immersion unit can be used at a depth of ten feet, or greater with longer lead

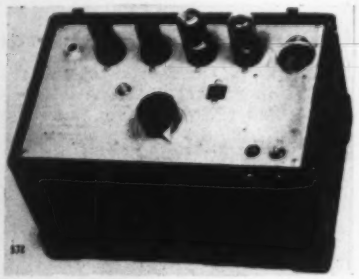


wires. Assembly consists of a plastic head, measuring elements, supporting pipe (not supplied) and a junction box. —*Leeds & Northrup Co.*, 4934 *Stenton Ave., Philadelphia* 44, *Pa.*

Mention No. 1140 when filling out card.

Calibrated Pre-amplifier

New "Model PR" calibrated pre-amplifier is especially designed to extend sensitivity of maker's line of recorders to 30 microvolts. A flat response from



40 to 40,000 cps., a dynamic range in excess of 60 db., and a calibrated gain control in 5-db steps from 0 to 50 db, give a calibrated amplification into a low-output impedance. Amplifier is available with a selection of input impedances for use with a multiplicity of low-output devices.—*Sound Apparatus Co., Stirling, N. J.*

Mention No. 1141 when filling out card.

Visual Circuit Tester

New "Cord Visual Circuit Tester" can be used by repair man or amateur to tell whether circuit is open or closed on fuses, pilot lights, transformer and coil windings, etc., where resistance is under 50 ohms. Using two penlight battery cells, device resembles a pocket

$3.19 Air Express cost helped this wildcatter strike it rich!

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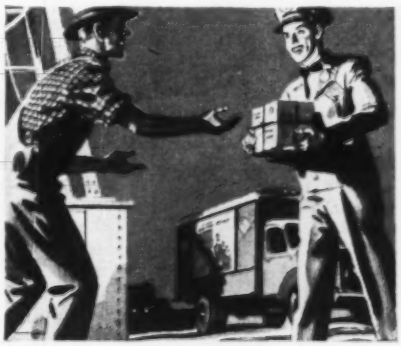
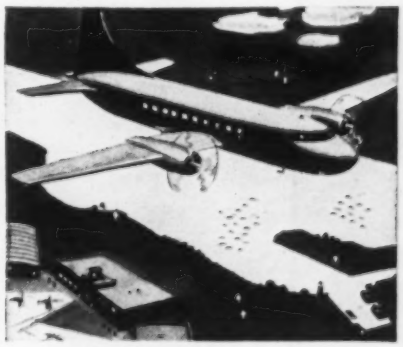


$3.19 was *complete* cost. Air Express charges include speedy pick-up and delivery service. Receipt for shipment, too. Makes the *world's fastest* shipping service exceptionally convenient.



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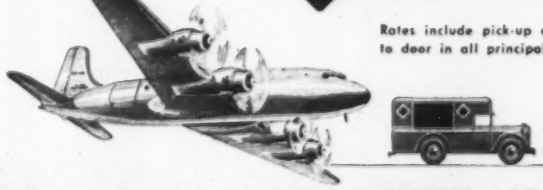

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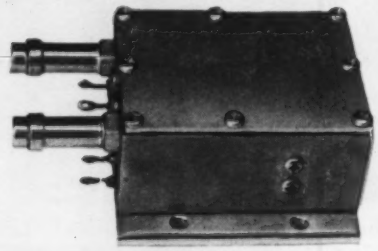

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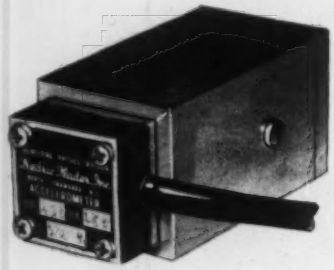

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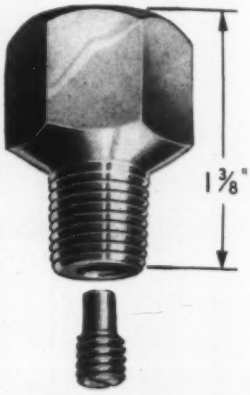
flashlight. Bulb lights up if the circuit is "good."—*Gits Molding Corp., 4600 W. Huron St., Chicago 44, Ill.*

Mention No. 1142 when filling out card.

Pulsation Damper

New pulsation damper for pressure gages is made with a cartridge of compressed powdered stainless steel and a steel body. No adjustments are

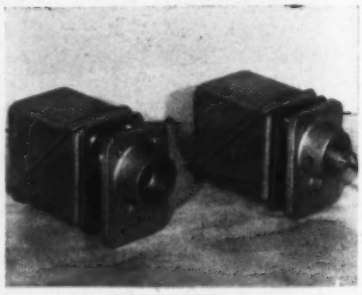


needed. Specific porosity of cartridge makes it effective for air, gas, water, steam or oil. Available for all pressures up to 10,000 psi.—*Helicoid Gage Div., American Chain & Cable Company, Inc., Bridgeport 2, Conn.*

Mention No. 1143 when filling out card.

Flame-failure Safeguards

New flame failure safeguards for combination gas-oil burners are applicable to installations which burn heavy grades of oil as principal fuel and gas as stand-by fuel, or burn gas as principal fuel and lighter grades of



oil as stand-by fuel. For heavy oil as main fuel and gas as a stand-by fuel, "System FF-2" consists of Photoelectric Scanner "45PH5," Flame Rod "45JP1" and Programming Control "24PJ8" which automatically starts burner in operation and programs the sequence of oil valve delay, post-ignition timing and priming period. For gas as main fuel and light oil as stand-by fuel, "System FF-6" includes Electronic Rod Type "24JQ1" and Control "24QJ5."—*Combustion Control Corp., 77 Broadway, Cambridge 42, Mass.*

Mention No. 1144 when filling out card.

A-c. Relay

New "No. 7064-919" relay, built for handling a-c. loads of 50 to 75 amperes at 115 volts a.c., 400 cycles, or 25 amperes at 270 volts a.c. 400 cycles, is provided with a 24-volt d-c. continuous-duty coil which operates on 157 ma.

and has specially-treated Bakelite construction adjacent to contact system for handling higher voltages. Relay pulls in hot at 18 volts and drops out at 7 volts or less. Contacts are also rated 50 amperes at 24 volt d.c. Contact system is s-p. s-t., n-o. double break. Weight is approx. 8.5 oz. Standard AN-3350 mounting bracket. Special modifications provide adequate insulation for breaking high-voltage loads at high altitudes. Temperature range—65 F to 160 F.—*Leach Relay Co., 5915 Avalon Boulevard, Los Angeles 3, Calif.*

Mention No. 1145 when filling out card.

Pressure-gage Bleeder

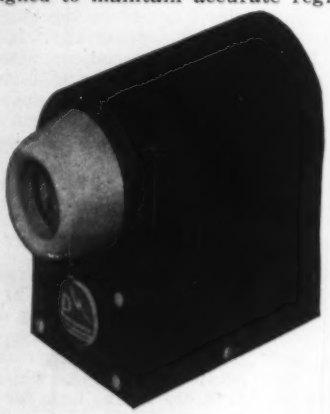
New integral capillary bleeder for use with maker's "Acragage" is designed for use in gages to be operated

on sealed hydraulic systems, or wherever pressure line must be purged. It permits complete purging of air from Bourdon tube at all times, eliminating possibility of inaccuracies which may amount to 4 percent of maximum scale graduation.—*Clapp Instrument Co., Tracy Court, Webster, Mass.*

Mention No. 1146 when filling out card.

High-speed Photoelectric Control

New "Type 23LF3" high-speed sensitive photoelectric control is especially designed to maintain accurate register



of paper and cellophane processed for bags and wrappers, also for various inspection applications, such as to detect presence of seams and blemishes in textile sheeting material. It is supplied with "Type 42KK1" scanner which consists of light source, phototube and amplifier tube in a single small housing of unique design. A common lens system is used, said to result in "smallest and most simply installed scanning

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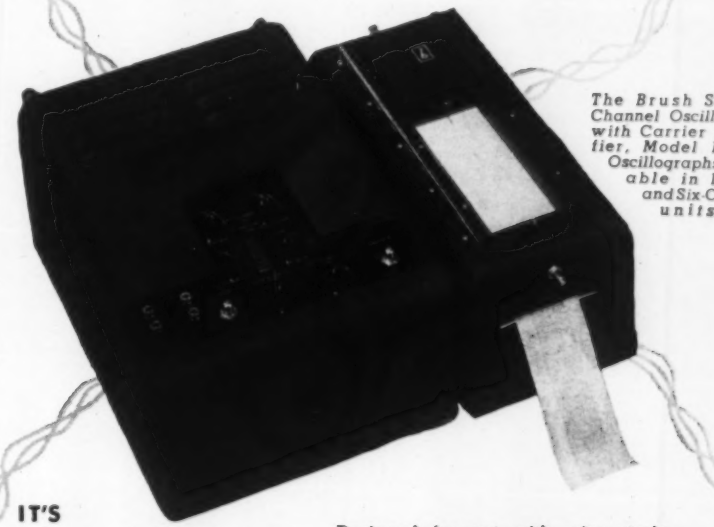
records of strains pressures temperatures torques vibrations or accelerations



The Brush Single-Channel Oscillograph with Carrier Amplifier, Model BL-310. Oscillographs available in Double and Six-Channel units also.

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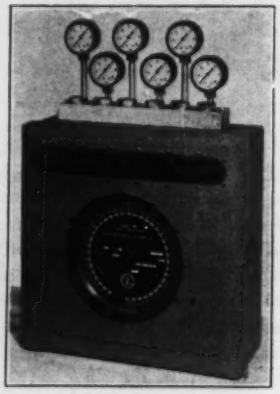

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head available to industry." Scanner is wired to new control with standard code-approved wire. Control consists of a power supply providing a.c. to light source and d.c. through a rectifier tube to phototube and a two-tube amplifier system. It is said the "Type 23LF3" is "the only photoelectric control of its type available which uses long-life extremely reliable vacuum tubes throughout the amplifying system and does not require gas-filled thyratron-type tubes."—*Photoswitch, Inc., 77 Broadway, Cambridge* 42, *Mass.*

Mention No. 1147 when filling out card.

Automatic Inspector for Connecting Rods

New automatic gaging, classifying and segregating machine for automotive connecting rods, gages completely for all critical dimensions and conditions, stamps with proper classification, and segregates at the rate of one

every five seconds. As an example, the accepted rods are automatically stamped with one of three 0.0001 in. classifications of the small hole diameter.—*Sheffield Corp., 721 Springfield St., Dayton, Ohio.*

Mention No. 1148 when filling out card.

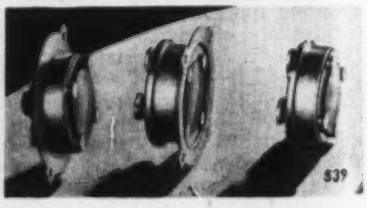
Thyratron

New "CE-329" xenon-filled thyratron is of particular interest to the aviation field; also useful industrially. It has the following characteristics: filament voltage, 14; peak inverse and forward voltage, 500; deionization time, 200 microseconds; average anode current, 3 amps. d.c.—*Continental Electric Co., Geneva, Ill.*

Mention No. 1149 when filling out card.

Thermostatic Switches

New "C4370 Klixon" fixed-temperature snap-action thermostats having enclosed contacts are suitable for products requiring non-adjustable temperature controls; are operated by maker's calibrated snap-acting disk which is mounted externally on the base for fast thermal response. Units are available with bottom mounting flange, top

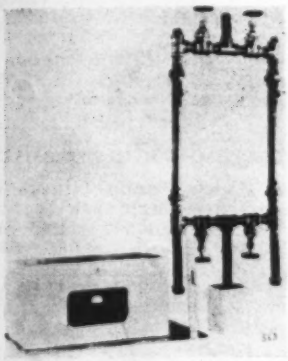


mounting flange and shoulder mountings; can be supplied with various temperature differentials in settings from minus 10 to 550 F. Also available with manual reset. C4370 listing includes a motor load rating of 0.25 hp, 120-240 volts a.c. and a pilot duty rating of 125 volt-amps, 120-240 volts a.c. Additional Underwriters' ratings include 12 amps, 120 volts a.c. and 6 amps, 240 volts a.c. For d.c. ratings, recommended maximums are 12 amps 30 volts d.c. and 1 amp, 125 volts d.c. All types are ground tested with 1500 volts a.c. —*Spencer Thermostat Div., Metals and Controls Corp., Attleboro, Mass.*

Mention No. 1150 when filling out card.

Electrostatic Air and Gas Filter

New "Midget Electronic Filter," for cleaning air and gases on applications where flow-rates are small, operates on electrostatic principles; is a standard "package" consisting of a filter unit and a power supply cabinet similar in size to a table model radio. Unit



comprises one or more ionizing-collecting cells each of 4-cfm. capacity, each cell using a tubular shell as a collecting plate and having an ionizing wire strung along center of tube. For larger flows, other pairs of cells up to 24-cfm. capacity may operate from one power supply. Cleaning efficiencies of 90 percent or better (by discoloration test method) are possible with filter. Equipment operates on 110-volt 60-cycle single-phase a.c. and consumes approx. 50 watts. *Trion, Inc.*, 1000 *Island Avenue, McKees Rocks, Pa.*

Mention No. 1151 when filling out card.

High-vacuum Rectifier Tube

New "Type 7X6" lock-in high-vacuum rectifier tube is supplied with a 6.3-volt heater rated at 1.2 amperes. Maximum rated output of 150 milliamperes and separate cathode leads make it suitable for a wide range of power-supply circuits—*Radio Div., Syvania Electric Products Inc.*, 500 *Fifth Avenue, New York* 18, *N. Y.*

Mention No. 1152 when filling out card.

Air-operated Butterfly Valves

New line of air-operated valves for process control is offered in sizes from 3 in. through 12 in. Assembly is installed in line with only one set of through bolts. 125-lb. drilling is standard. Accessibility is good because face-to-face dimensions are small. Valve

6 TO 1 ONE Indicator Plug Connects to any of SIX Thermocouple Jacks

MULTI-POINT PYROMETER INDICATOR

Fast Simple Versatile Accurate Compact Trouble-Free

Designed to indicate temperatures for various applications.

Indicator is automatically compensated for cold junction temperature changes and instrument temperature resistance coefficient.

Available in five temperature ranges, either Fahrenheit or Centigrade.

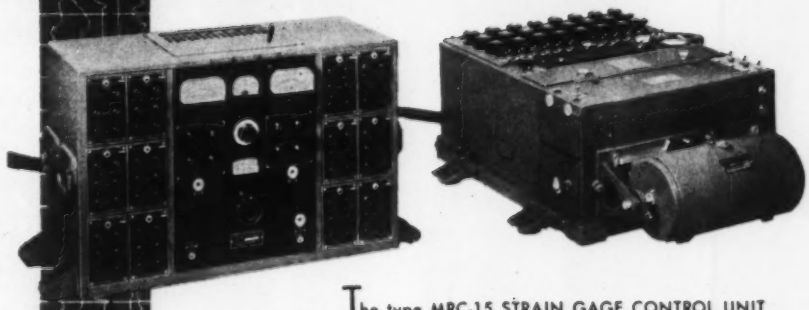
Maximum accuracy is obtained because Polarized Plugs and Jacks are of thermocouple materials, eliminating errors produced by unmatched elements.

The coupling plug quickly connects the pyrometer to any of the six thermocouple jacks.

If you will advise us the details of your application, we will recommend suitable equipment or, for additional information request our Catalog Section 25 F

Thermo ELECTRIC CO. FAIR LAWN, N.J.

Strain Recording Equipment



The type MRC-15 STRAIN GAGE CONTROL UNIT and the type S8-B OSCILLOGRAPH make up a complete strain recording laboratory. The MRC-15 contains complete equipment to power strain gages and to drive oscillograph galvanometers for recording from static strain to a frequency of 5000 cycles per second. It is complete with strain gage balancing controls, precision calibrating device, and power supply equipment.

The S8-B, with 12 to 48 elements, is a highly-refined general-purpose oscillograph with chart speeds of ½ to 40 inches per second designed to accommodate a wide range of galvanometer types and characteristics. Precision optical system insures records of highest accuracy and quality. Many refinements contribute to versatility and convenience.

Write for Technical Bulletins

For the MRC-15, Bulletin No. SP-195H • For the S8-B, Bulletin No. SP-165H

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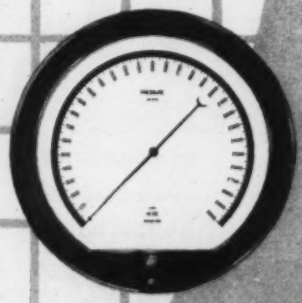
dial scale is always concentric with the pointer travel



HEISE GAUGES

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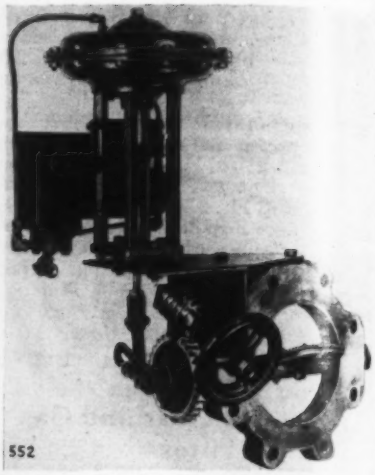
The scales of Heise Bourdon tube pressure gauges are absolutely concentric with the pointer rotation. Errors due to misalignment in mounting or cutting the scales are avoided since the scales are cut from their centers, and are mounted at the centers on a hollow spindle through which the pointer rotates.

Three sizes: 8½ in., 12 in., and 16 in., in ranges from 0-15 to 0-10,000 psi. Prices from $151.60 to $211.20. Write for catalog.

Heise Bourdon Tube Company, Inc.
Newtown, Connecticut



bodies are available in carbon steel, bronze, 316 stainless steel, and other materials including plastics: vane is 316 stainless, fitted with rubber seal when required. Static line pressures up to 125 psi and differential pressures up to 50 psi can be handled. Valves are supplied with hand jack screws, air-operated diaphragms, and valve positioners.—*Fischer & Porter Co., Hatboro, Penna.*

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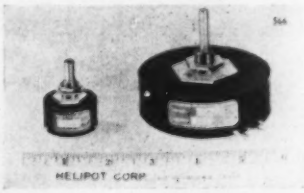
Voltage-dividing Resistors

New "Models F and G" linear "potentiometers" are single-turn "potentiometers" with continuous rotation. Smaller

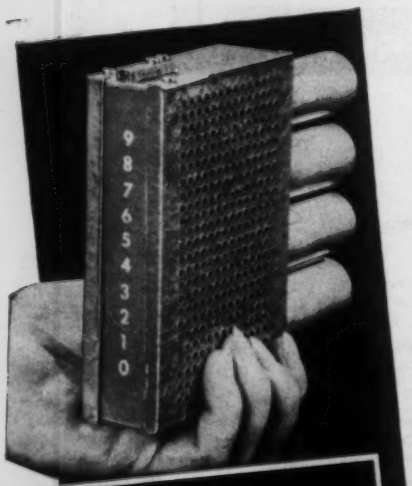


"potentiometer" is particularly adapted to transmitting use and aircraft installation. Larger unit is especially designed and engineered for computer systems. Units will be available in standard primary types as well as custom built.—*Helipot Corp., South Pasadena, Calif.*

Mention No. 1154 when filling out card.

Miniature Clutches

New model clutches are made as standard stock items to accommodate mass-market of small-motor applications in industry and home workshops; however, each packaged unit is fur-



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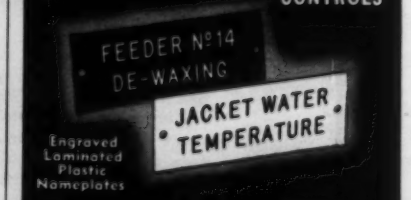

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nished with complete adjustments and instructions to adapt it to a wide range of characteristics. Versatility is accomplished by comparatively simple adjustments of friction segments (shoes) and of springs. Besides adjustments for capacity, pulley-type clutches can accommodate several standard sizes of pulleys.—*Centric Clutch Co., Cranford, N. J.*

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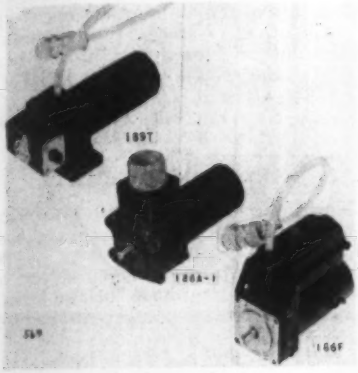
Rotary Servomotors

New "Series 186, 188 and 189 Rotary Actuators" are provided with (1) split-field, reversible explosion-proof d-c. motor, (2) electromagnetic brake, (3) planetary gear assembly and (4) circuit switch assembly within a small en-



velope with weight reductions up to 75 percent over former models. Standard gear assemblies are designed to withstand a maximum load of 45 oz.-in. with special designs up to 200 oz.-in. *Lear, Inc., Electromechanical Div., 110 Ionia Ave., N. W., Grand Rapids 2, Mich.*

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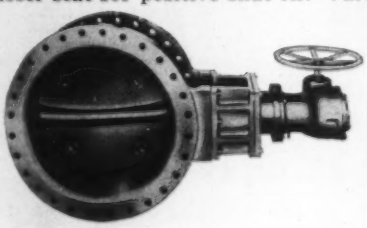
Rubber-lined Valve

New "Type No. 709" is a 30-inch 50-lb. cast iron valve equipped with 125-lb. flanges and a renewable one-piece rubber seat for positive shut-off. Valve



is air bubble tight at 80 psi. and drip tight with water at 100 psi. Temperature range is minus 20 to plus 200 F. Easily adapted to automatic control, valve is available in smaller or larger sizes, in all materials and for higher pressures.—*R-S Products Corp., Wayne Junction, Philadelphia 44, Pa.*

Mention No. 1157 when filling out card.

Miniature Relay

New "Model SM" sub-miniature relay, with windings as high as 8,000 ohms and adjustment for current operation to pull in as low as 3 ma., with coil consumption of 75 milliwatts minimum, wound for d-c. voltage actuation, draws approximately 0.5 watt. Maximum dis-

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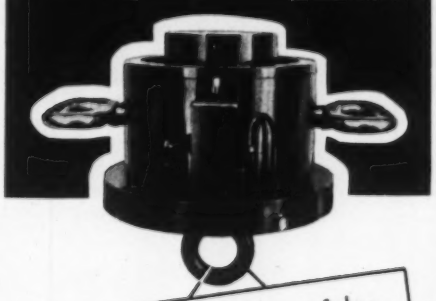

for use in applications such as dynamometers, industrial weighing, strength of structures, jet engine thrust, and countless other force-measuring problems. Illustrated is the famous Emery Hydraulic Cell, basic unit of Emery hydraulic testing and force-measuring systems.

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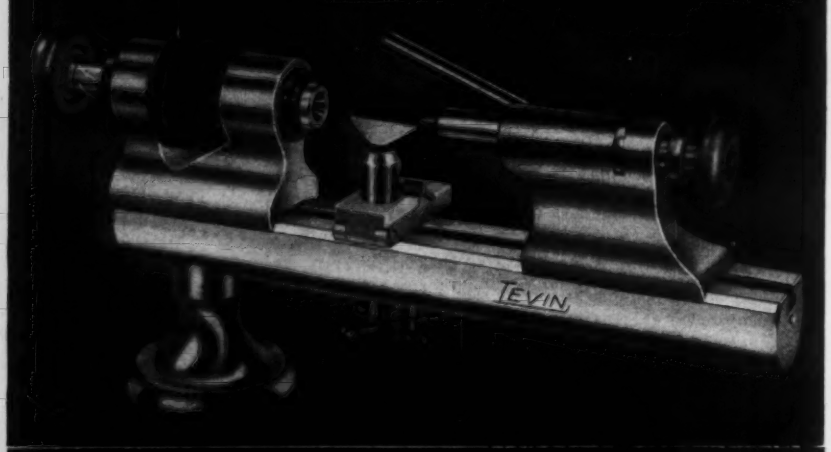

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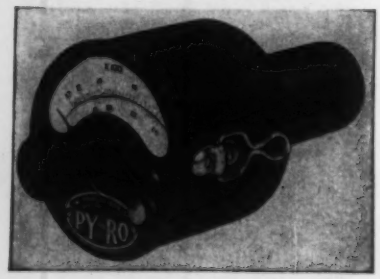

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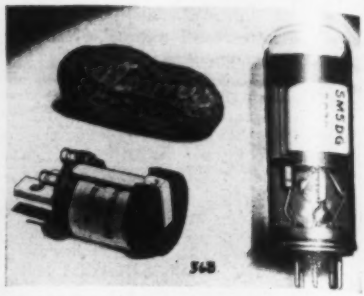

sipation is 1.75 watts at 83 °C. rise. Volume is less than 0.25 cubic in. and weight less than 0.5 oz. Contacts are pure coin silver rated at 0.25 amperes at 115 volts, 60 cycles. Contact combination is s-p.d-t. or one "Form C." Relay is available in either open type or hermetically-sealed in a miniature glass tube envelope with a 7-prong base. —*Potter and Brumfield, 549 W. Washington Boulevard, Chicago 6, Ill.*

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Selenium Rectifiers

New dual selenium rectifier elements, dimensions 7.25 x 12.75 in., handle up to 85 amps. continuous duty or 340 amps. intermittent. Elements are assembled in three-phase bridge heavy-duty 10-kw. rectifier stack rated at 1500 amps. Stacks are designed on a basis of 16 kw. per cu. ft.—*International Rectifier Corp., 6809 S. Victoria Ave., Los Angeles 43, Calif.*

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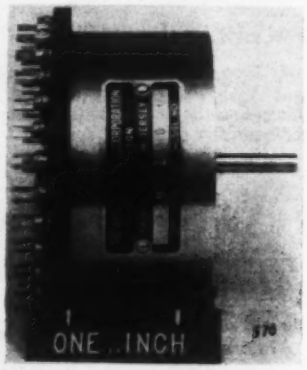
Motor-driven Switch

New "High Speed Mechanical Sampling Device" provides clean and reliable switching at sampling rates up to and exceeding 5,000 cycles per minute. Sixty



make-before-break contacts are sampled each cycle. Switches with 30 contacts are available with even higher sampling rates. Switch is so designed that it may be driven by an external shaft, may also be furnished in one unit with driving motor of any design or speed within above limits.—*The Applied Science Corporation of Princeton, Princeton, N. J.*

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Multi-pole Relays

New "Bulletin 110" multi-pole midget magnetic relays are designed for general and special-purpose control use. Standard 2- or 3-pole double-throw relays have molded phenolic insulating bases, screw terminals for front con-

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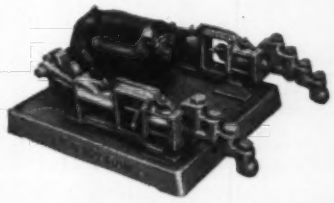

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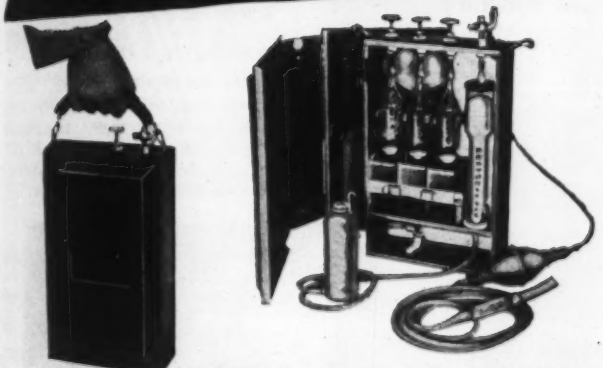

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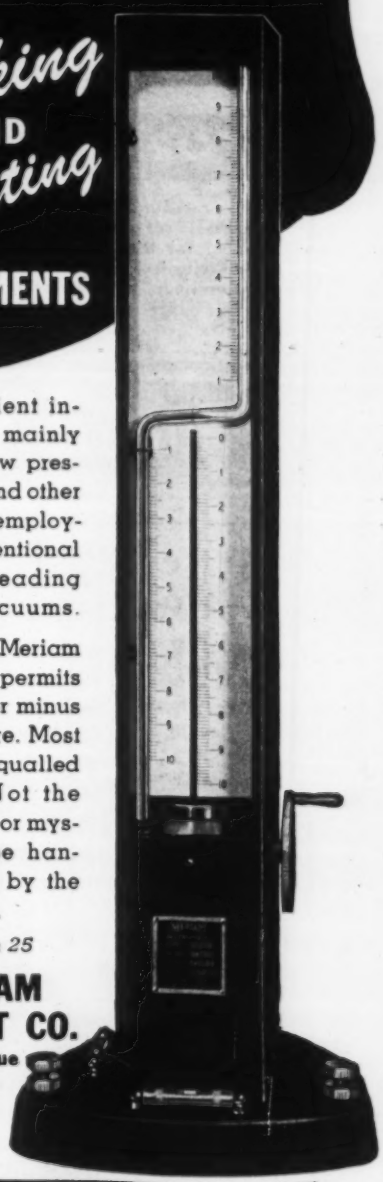

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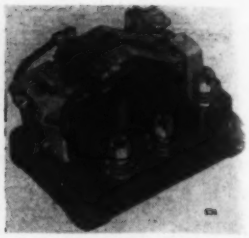

nection and heavy silver to silver contacts. Leads from movable leaf spring contact fingers to terminals are insulated with Fiberglass tubing. Coils are available for operation on all standard voltages and frequencies up to 115 volts a.c. or d.c. Non-inductive ratings for n-o. and n-c. contacts are 10 amps, 24 volts d.c. or 115 volts a.c. 60 cps.—*Ward Leonard Electric Co., Mount Vernon, New York.*

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Aircraft Navigation Radios

New "Model LR-5BN" VHF receiver and "Model RT-10CH" VHF transmitter are designed for installation in aircraft instrument panels. Receiver

has continuous tuning for all VHF Tower, Radio Range and VOR reception facilities. Weight 4 lbs., 4 oz., over-all size less than 3.5 x 6.5 x 7.75 in. 2-watt, 6-frequency transmitter weighs 13 oz., overall size 3.25 x 3.25 x 7 in.—*Aircraft Radio Div., Lear, Inc., 110 Ionia Ave., N. W., Grand Rapids 2, Mich.*

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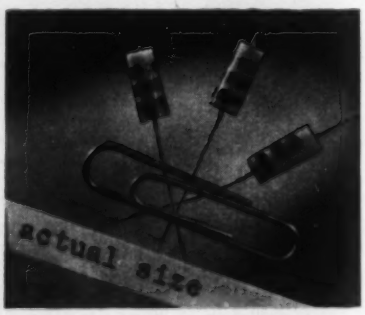
New "Types CK705, 706, 707, and 708" germanium diodes are 0.390 in. long and 0.160 in. diameter, marked with a color code, and possess a high ambient operating temperature rating of 100C. and resistance to change in



humid atmospheres. Higher temperature rating is obtained by using only glass and metal in the basic assembly. In addition to total immersion this design has withstood more than 72 hrs. exposure to 95 percent humidity at temperatures from 25 C. to 70 C.—*Special Tube Section, Raytheon Mfg. Co., 55 Chapel St., Newton, Mass.*

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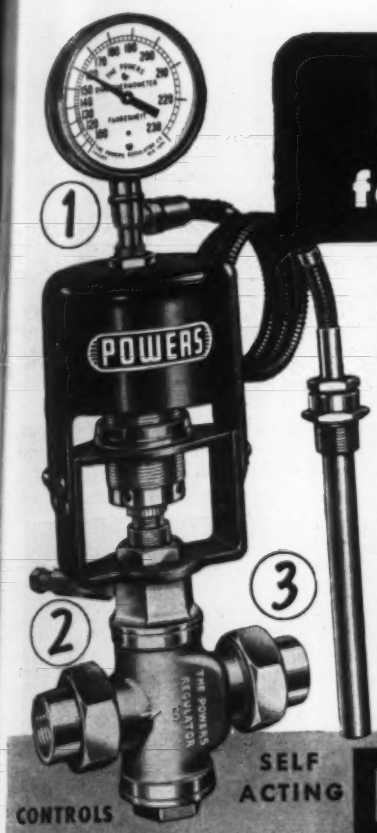

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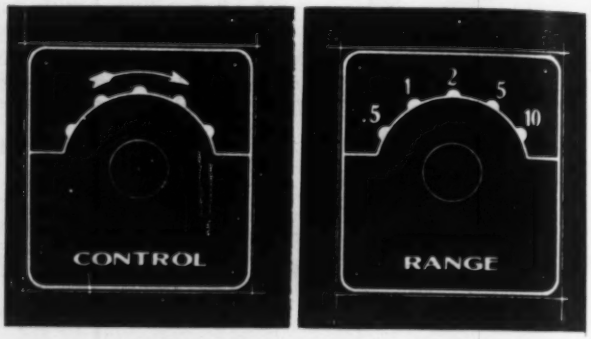
Photographic Type Dial Plates

By EDWARD CARTOTTO, Glendale, Calif.

THERE is always a lot of apparatus built by a laboratory for its own use. Shop facilities are usually adequate for producing the chassis, panels, and cabinet, but invariably means are lacking for making appropriate identification plates and dial plates.

Two professional-looking dial plates are illustrated in the accompanying photograph. The technique for producing these consists of drawing the dial plate on vellum with India



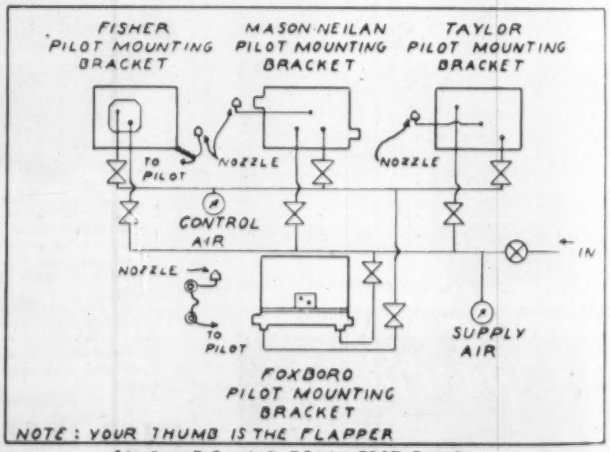
ink and applying good, neat lettering with any of the mechanical lettering aids. Glossy photographic prints are made using the vellum as a negative. Finally, the prints are trimmed to size and protected by a thermo-setting plastic envelope. This plastic coating process is available through most blueprint supply houses.

This technique is simple, inexpensive and flexible. It lends itself well to small production runs where complicated, individually-engraved plates are too difficult to make and quantities involved are too small to warrant procurement of commercially-etched dial plates.

Instrument Relay Valve Test Panel

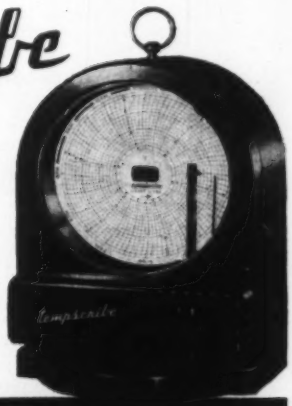
By J. R. KACHELHOFFER, Lockport, Illinois

The testing device shown on the attached drawing greatly simplifies the testing and adjusting of most of the commonly used instrument air relays. Its compactness and ease of operation make this test panel an asset to any instrument shop.



SCHEMATIC - AIR RELAY TEST PANEL
DESIGNED BY: J. R. KACHELHOFFER DRAWN BY: D. ARMSTRONG

tempscribe



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-10° to + 50° F	7 Days
-10° to + 50° F	24 Hours
30° to 60° F	24 Hours
40° to 100° F	7 Days
40° to 100° F	24 Hours
60° to 90° F	24 Hours
60° to 90° F	8 Hours
70° to 130° F	24 Hours
70° to 130° F	8 Hours
100° to 160° F	4 Hours
-25° to + 10° C	24 Hours
5° to 40° C	24 Hours

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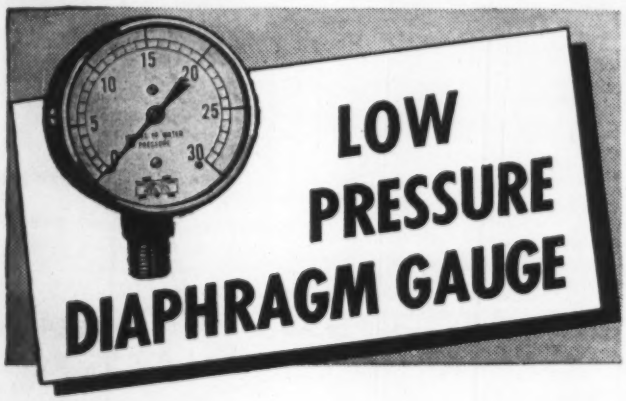

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Organization of an Instrument Departme

Continued from page 1003

trometers, infrared and ultraviolet spectrophot meters. It is true that in many cases contracts with ba gaining units make selection of qualified personnel nearly in ossible. This article does not attempt to solve this problem but the fact remains that a great amount of the highest type of instrument work is being lost to industrial Instru nt Departments because of the lack of qualified perso el.

Special Electronic Sections have been established n many process plants, and their place in the Organizatio Chart may be anywhere.

V. Responsibility and Relationships

As noted before, and important enough to repeat: the primary responsibility of an Instrument Department organization is to the Process.

Some of these responsibilities already have been mentioned, such as maintenance of instruments. Others include:

1. Assist operators in putting units into operation; in maintaining operations, and shutting down units.
2. Compile repair lists on routine or turn-around work.
3. Recommend revisions, additions or dismantlings to improve operations or conserve material.
4. Assist in design of new equipment.
5. Furnish safety information to operators.

To the Mechanical Superintendent the Instrument Department is responsible for:

1. Mechanical work involved in construction and repair.
2. Coordination of instrument mechanical work with other mechanical crafts.
3. Maintenance of mechanical equipment used by the Department as well as additions or revisions to same.
4. Working agreements with other crafts.
5. Furnishing estimates on cost of instrument work, when requested.
6. Maintaining and coordinating storehouse stock of instrument material.

The Instrument Department Foreman should be responsible to the Personnel Director for:

1. Carrying out over-all company policies.
2. Protection of individual employees within the Department with respect to their rights to benefits provided by policy. (This may include clerical work involved in vacations, sickness benefits, transfers, etc.).
3. Depending on plant policy: agreements with other crafts.

The Department is responsible to the Safety Supervisor for:

1. Formulating any special safety rules peculiar to the work of the Department.
2. Obtaining compliance with special and general safety rules.
3. Investigation of accidents.
4. Execution of all clerical forms required.

The Department is responsible to the Chief Storekeeper for:

1. Originating initial orders or requests for material not normally carried in stock.
2. Establishing minimums.
3. Disposal of obsolete stock.
4. Advising on substitutions where necessary.
5. Establishing standards and minimizing duplication.
6. Clerical work necessary in removing material from or returning material to storehouse stock.

The Department should be responsible to the Chief Metal Inspector for:

1. Reporting instances of severe corrosion, erosion or unusual material failures. This practice is quite advantageous because the control valves usually take most of the pressure drop in a process. Failures in these valves may give a warning of unfavorable or dangerous conditions in the rest of the equipment.
2. Furnishing assistance or reports when requested in making tests of new materials.
3. Obtain approval where necessary on design of new equipment which may be subjected to process pressures and temperatures.

The Department is responsible to the Chief Design Engineer for:

1. Furnishing information on performance of instruments and related equipment.
2. Recommendations or advice on engineering standards pertaining to instruments.
3. Furnishing information and consulting with engineering staff on instrumentation problems on new construction.
4. Approval or advice on instrument layouts on all engineering projects.

I do not know whether an Instrument Department exists, anywhere, that meets all of the requirements given here. Neither will there be complete agreement within the ranks of instrument engineers and instrument foremen. However, if one or two points are scored, some of us may be near our objectives.

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Regulation of pH

Continued from page 1011

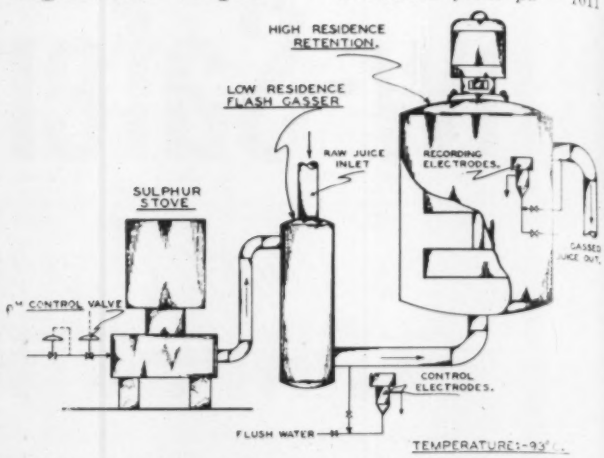


Fig. 71. Schematic layout of typical low-residence beet sugar sulphitation process.

tration of sulphur dioxide generated depends upon the supply of air admitted to it. This process, like the previous one, has a low buffer index but gassing is done in a low-residence flash-gasser followed by high-residence retention. The major advantage of this process is that over-gassing and consequent "burning" of the sugar, as sometimes occurs in high residence gassers, is minimized.

(E)

One frequently encounters unique pH control problems in the chemical manufacturing industry. They are usually individualistic problems requiring specific analysis and special techniques for control application. Fig. 72 is representative of such a problem and applies to a process wherein two liquids are reacted to form a liquid product. The product does not lend itself readily to analysis by industrial instrumentation, but a gaseous by-product, having acidic characteristics, is generated in relationship to product formation.

To this process, therefore, pH control is applied indirectly by measuring pH of a constant-volume sample of stack gases blended with a metered volume of water. Reactant feeds are controlled by ratio-flow regulators whose ratio is adjusted by pH recorder pHC-1. Fortunately, buffer index

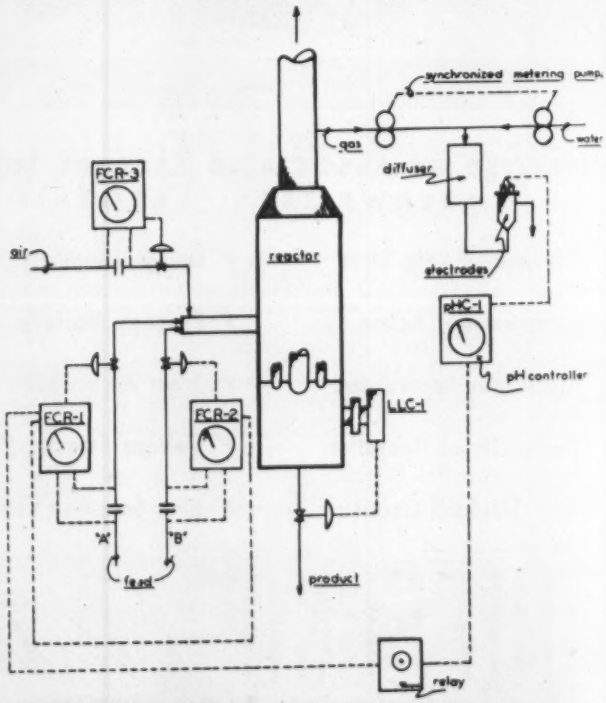
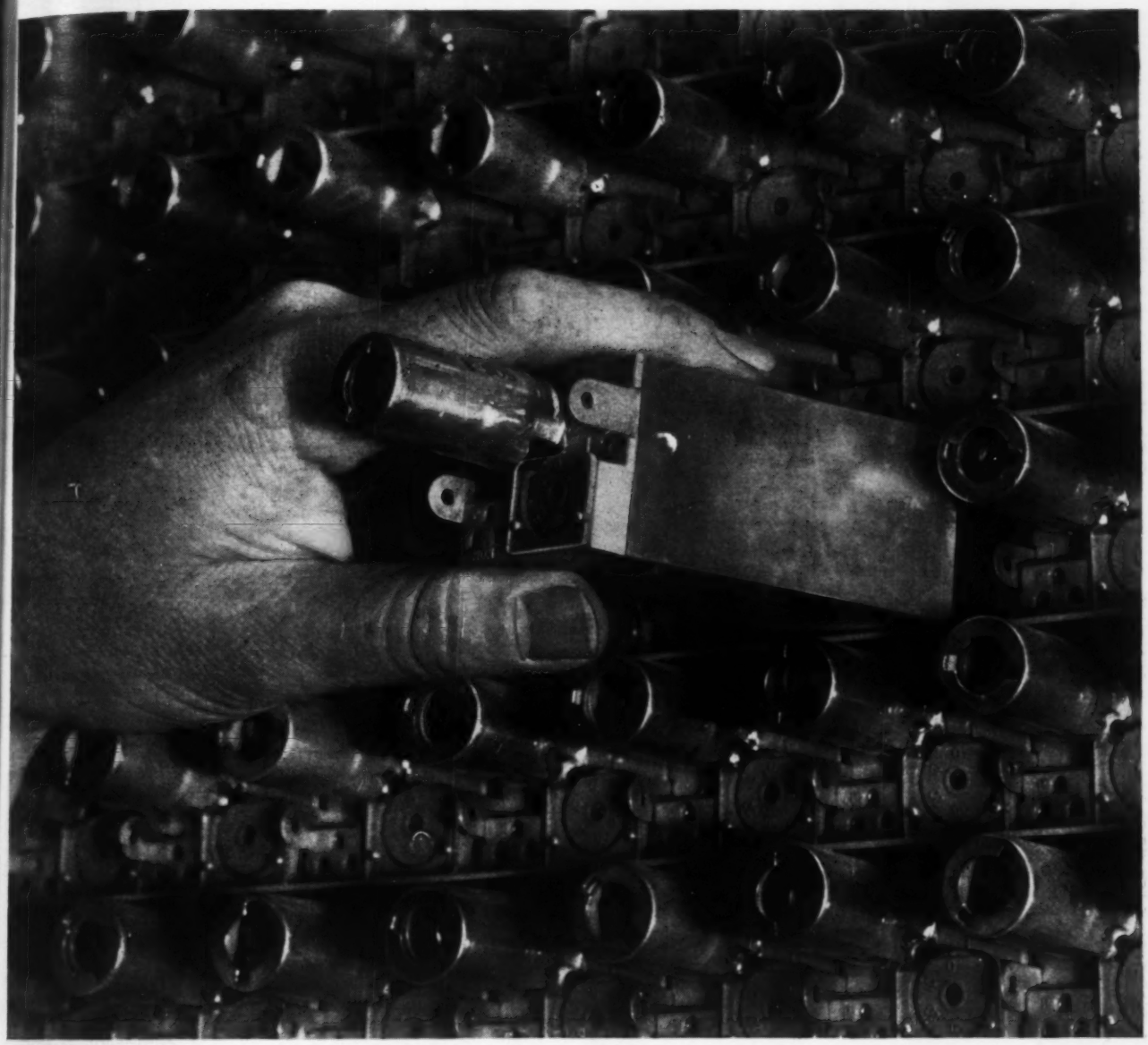


Fig. 72. Indirect application of pH control to regulate process by measurement of side product stack gases.



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battle of the inches

It takes many costly buildings to house your telephone system. Every inch saved helps keep down the cost of telephone service. So at Bell Telephone Laboratories engineers work constantly to squeeze the *size* out of telephone equipment.

In the picture a new voice frequency amplifier is being slipped into position. Featuring a Western Electric miniature vacuum tube, tiny permalloy transformers, and special assembly techniques, it is scarcely larger than a single vacuum tube used to be. Yet it is able to boost a voice by 35 decibels. Mounted in a bay only two feet wide and 11½ feet high, 600 of the new amplifiers do work which once required a *room* full of equipment.

This kind of size reduction throughout the System means that more parts can be housed in a given space. Telephone buildings and other installations keep on giving more service for their size – and keep down costs.

The new amplifiers, which will soon be used by the thousands throughout the Bell System to keep telephone voices up to strength, are but one example of this important phase of Laboratories' work.

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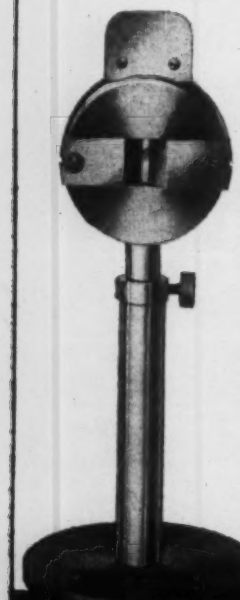
EPLAB

Thermopiles



For many years the thermopile has been the accepted instrument for measuring Radiant Heat from Radiant Heaters at the American Gas Association Testing Laboratory in Cleveland, Ohio. Since 1930, when Vandaveer first described his work in this field,* an Eppley thermopile has been used for this purpose in hundreds of tests and the results have been consistent and accurate to within 1 per cent.

This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.

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*Vandaveer, Industrial & Engineering Chemistry, Vol. 22, page 596, June 1930.

BULLETIN NO. 340 ON REQUEST

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of the reaction is low and the installation has proved to be satisfactory—although it is desirable, as a general rule, to apply direct measurements wherever possible.

This method may be applicable to processes having limitations similar to the one described, but it is not recommended for general use. The ratio of stack gas composition to production rate of the process may not be linear and a rising pH beyond stoichiometric maximum for one rating may cause the pH regulator to do the wrong thing. This condition was obviated in the process described by operating at a stack pH slightly below stoichiometric maximum and restricting variations in production rating to a narrow limit.

It should further be noted that pH of the dilution water must be constant. This condition obtains fairly well with municipal or treated industrial water supplies and, as a rule, these waters are sufficiently well buffered to introduce no objectionable errors into industrial pH measurements. Distilled water or condensate cannot be used.

(F)

Sometimes it may be desirable to use pH as a measurement of salt or acid content of strong solutions, but conditions of ionization or buffering effect make the measurement insensitive at the concentrations involved. It may be possible, in some cases, to use other methods such as conductivity measurements which do show ample sensitivity in the required ranges, but it was found, in connection with the process to be described, that it was more convenient to use pH as a measure of acid strength in a range of concentration where conductance characteristics exhibited a "foldback" or reversal of characteristics.

Strong acid, having a pH ranging from 1.0 to 2.0, was to be reacted with an alkaline material, but sensitivity of the pH variable at the low values involved was inadequate to permit accurate dosage. A special alloy pump of the proportioning type was available and was used to meter a few cc's per minute of untreated acid and the required volume of plant water to raise pH to approximately 5.0 where the acidity characteristic is steep and extremely sensitive to small changes in acid strength. A diffuser, consisting of a section of pipe with internal baffles, was connected to the common discharge line from the pump, and ahead of the electrodes to blend the metered liquids as illustrated in Fig. 73.

The control engineer may find similar applications of the method to other concentration measurements, but it should not be applied without analysis since, aside from added transfer lags, there are two major limitations, the most serious of which is the necessity for special alloy pumps to handle concentrated acids of a corrosive nature. Secondly, a change of 1.0 pH corresponds to a ten-fold change in concentration of H^+ ions and errors of metering the acid and water are amplified in the higher pH ranges. The same amplification of pH changes occuring in the strong acid applies in the higher pH range, but such amplification is not a limitation since corresponding percentage changes are similar. In general, the principle is unique and offers many advantages for laboratory or pilot-scale investigations but its production unit use is not to be regarded as good engineering practice.

(G)

Another interesting application of pH control is in commercial air conditioning where it is applied as an *operations check instrument.**

The humidification unit of an air-conditioning system passes the treated air through a controlled water spray, from which the water is recycled through intermediate processing stages. Carbon dioxide, from exhaled human breath, collects in the recycled humidification water and must be removed by controlled alkali additions and/or regulated purge. The process illustrated in Fig. 74 has a fixed purge and pH is regulated by controlled caustic feed. Other, more modern, processes may remove carbon dioxide without frequent purge, but pH may be used as an index of acid content.

(H)

Experimental studies on pH control of pulp digesters have provided an interesting application for automatic control equipment. It is not customary practice to measure or

*For definition and description of operations check instruments, see "Analyzing the Instrumentation of a Continuous Chemical Process," by A. L. Chaplin, *Instruments*, Vol. 21, June 1949, pages 532-540.

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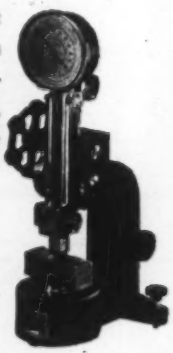

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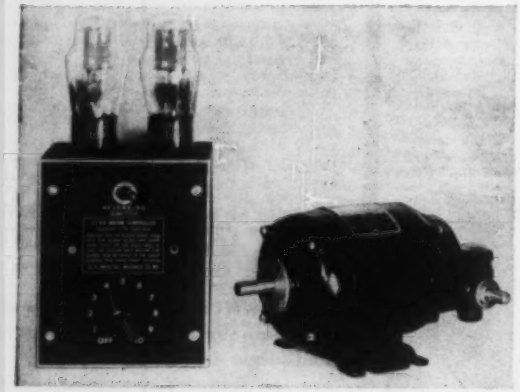

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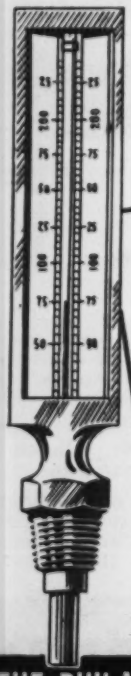

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control pH of production digesters but experiment[al] studies made on a research pilot-plant scale have necess[itated the] development of techniques which may be applicab[le] to similar unusual processes.

The process operates at elevated pressure and [tempera]ture, thus necessitating forced injection of conro[l] reagent into the system. Furthermore, the high-temperatu[re] liquors must be cooled to a range within limitations of the e[lectrodes]. The experimental process illustrated in Fig. 75 is an [in]direct-cook circulating process wherein an acidic chemi[cal] is injected at the suction side of the circulating pump. A positive displacement feed pump, provided with a return [pressure] regulator and ballast tank, was used to supply reag[ent] to a conventional throttling control valve. However, mo[re] recent developments in the direct throttling control of positive-displacement pumps have made them very attractive as reagent feed devices and one might find cost advantages in applying them to high-pressure processes instead of control valves.

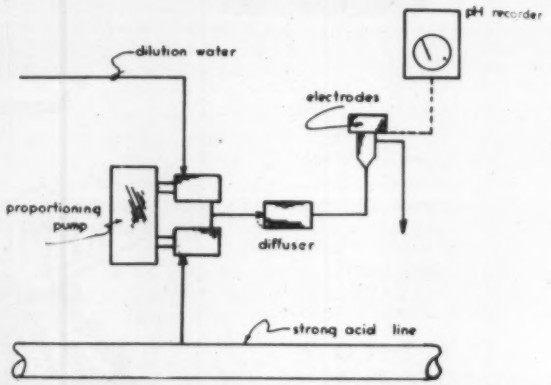

Fig. 73. Continuous dilution of metered sample of strong mineral acids increases measured pH to more sensitive region of acidity characteristic. Dilution water must be well buffered at constant pH. Municipal or treated industrial water supply is satisfactory. Distilled water is not recommended.

The effect of reducing temperature of the process liquor for continuous measurement in an outboard flow assembly is to cause an increase in pH. In other words, the true pH of any solution depends upon its temperature and, should the liquor within the processing vessel be at a higher temperature (within a maximum limit of approxixmately 460°F., see Fig. 76), its true pH will be lower than the true pH of the cooled liquor at the electrodes. This temperaure effect is characteristic of most all aqueous solutions and the actual magnitude of pH change with temperature depends upon the coefficient of the specific solution measured.

The temperature compensator of electrode assemblies does not correct for this effect: its function is to correct the

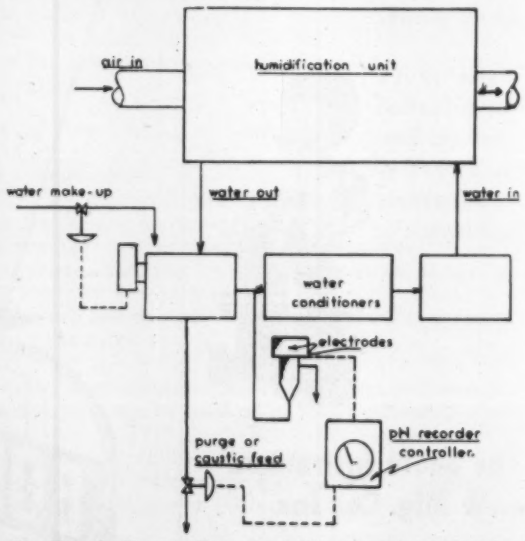

Fig. 74. Use of pH controller as operations check instrument in air-conditioning process. Controls caustic addition and/or purge to remove CO_2 from humidification water.

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S-10	1/10 sec.	1000 sec.	±.02 sec.
S-6	1/1000 min.	10 min.	±.0002 min.
S-1	1/100 sec.	60 sec.	±.01 sec.
MST	1/1000 sec.	.360 sec.	±.001 sec.
MST-500	1/1000 sec.	30 sec.	±.002 sec.

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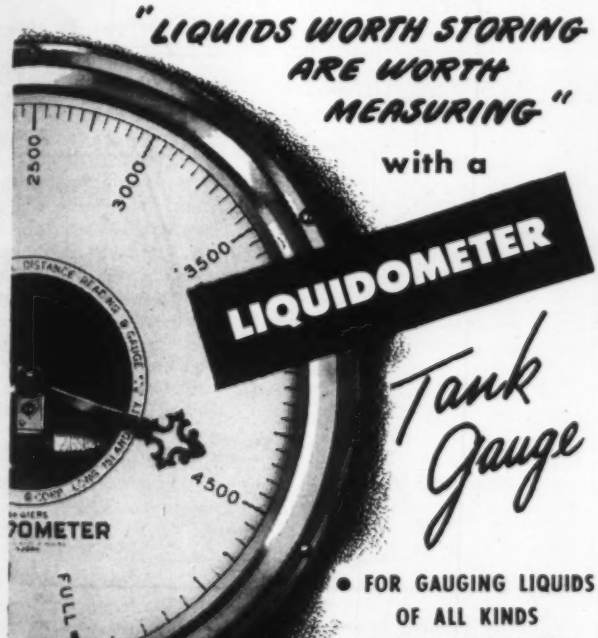

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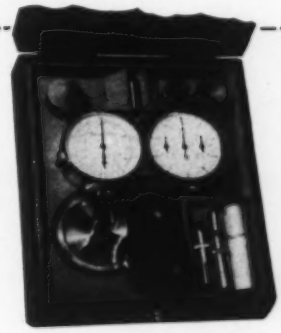

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"E — pH" relationship of the glass electrode which also varies with temperature. If the electrode is so compensated for temperature, it will indicate the correct pH of the solution at the temperature of measurement. However, the liquor within the vessel will be at a different pH which can be estimated by adding algebraically the true measured pH and the product of the liquor coefficient and temperature difference. Moreover, coefficients are not linear with temperature and the accuracy of interpolation will depend upon the temperature of operation and temperature difference at the electrodes.

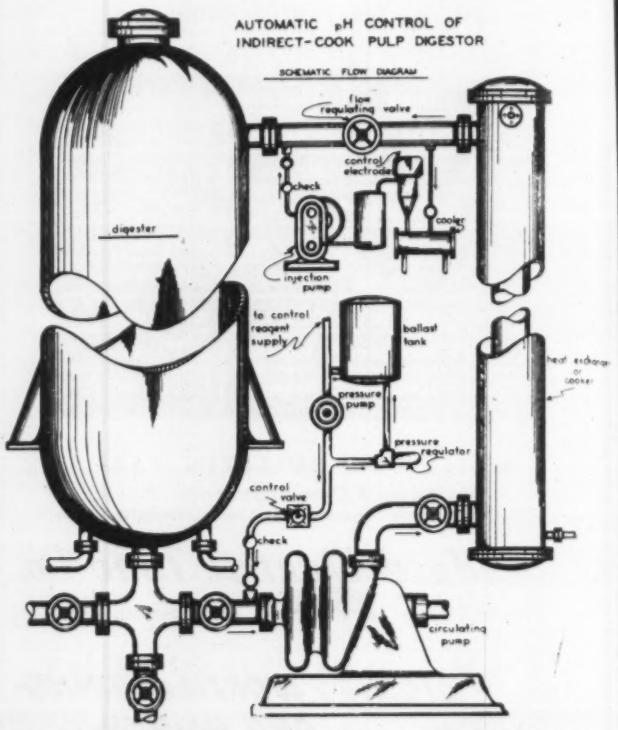


Fig. 75. Application of automatic pH control to experimental pilot-scale indirect-cook pulp digester.

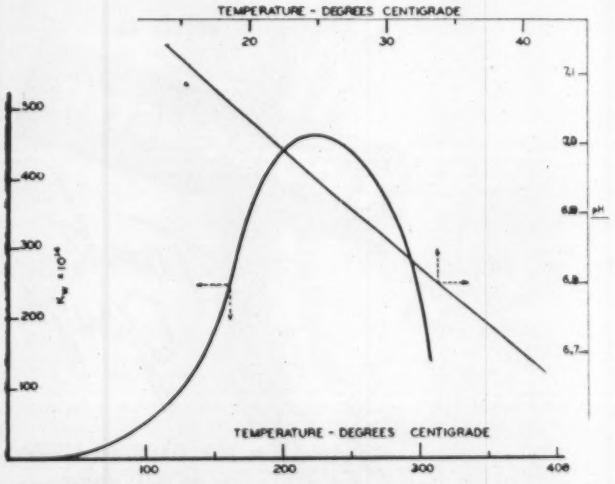


Fig. 76. Relationship between temperature and pH of pure water at neutrality.

The technique of cooling measured sample is used quite widely in the application of concentration instruments because the limitations of existing primary elements restrict them to moderate ranges of temperature and pressure where the majority of industrial applications are found. Until such time when temperature and pressure limitations can be extended beyond present ranges, such special applications as the one described may require similar techniques in application engineering.

To be continued

JOURNAL of the Instrument Society of America

I.S.A. National Office, 921 Ridge Ave., Pittsburgh 12, Penna.

Vol. 5 NOVEMBER 1949 No. 11

The Recommended Practices Committee of the Instrument Society of America

By HAROLD M. McCARTHY*

SHORTLY after the Society was organized on a national basis, a small group of the charter members got together to discuss ways and means by which the Society could contribute to industry. It was determined that among the membership were many individuals who possessed years of experience in the field of instrumentation and automatic control. These people, if organized into technical committees, would be able to pass on valuable knowledge and experience in the form of recommended practices.

In the fall of 1946, these early discussions culminated in the formation of the Recommended Practices Committee of the ISA. The objectives of the committee were defined as follows: "To study technical practices in instrumentation; to prepare and recommend uniform practices where adoption of such uniformity would simplify work and facilitate general understanding; and to promote their general adoption."

The scope of the committtee work is confined, in general, to the study of technical practices of an engineering nature. Research, design and development of new equipment or materials, or projects of similar nature, are not considered a function of this group. Suggestions or assistance along these lines are conveyed to other technical committees or societies.

The membership of the Recommended Practices Committee is limited to a maximum of twenty-five engineers who are actively engaged in the field of measurement and automatic control. The chairman is elected from this group. Approximately one-fifth of the members perform liaison work with other professional or technical societies. The function of each member of the RPC is to act as chairman of a subcommittee. Each subcommittee is organized by the subcommittee chairman, who selects the individuals to work with him as members of his subcommittee, with the object of preparing tentative recommended practices for a particular type or phase of instrumentation with which his subcommittee is most familiar.

Procedure for selecting technical subjects or projects for investigation is handled by a survey group established by the Recommended Practices Committee. The function of the survey group is to establish whether a suggested project would benefit users and/or manufacturers of instruments. If the results of the survey establish the necessity or desirability of further work on the subject, a recommendation to that effect is made to the Recommended Practices Committee. The liaison members of the RPC advise if the other societies or associations they represent have any similar projects which would conflict with the one proposed. If no conflict is indicated, the RPC establishes the subcommittee, defines the scope of the project, makes recommendations on the program and personnel of the subcommittee, and selects the subcommittee chairman. The project is given a number and the subcommittee is thus established.

The subcommittee chairman organizes has subcommittee from qualified individuals residing in local geographical locations in order to facilitate ease of travel to attend meetings. Various means are used to obtain opinions from users, manufacturing and contractor engineering groups. This information is collated to form the basis for a report for presentation to the Recommended Practices Committee. The report is reviewed by all the members of the RPC who submit their comments and suggestions to the chairman of the RPC. This information is passed on to the subcommittee chairman who takes the action indicated by the majority of the comments. The report is revised or corrected as necesary and is then resubmitted to the RPC for promulgation into a tentative recommended practice.

After the "Tentative Recommended Practice" has been validated for publication, it is printed and distributed to the members of the Instrument Society of America for inclusion in the ISA looseleaf binder. This volume, issued to all members of the ISA, will constitute a valuable handbook for instrument engineers.

*Reporter of Recommended Practices Committee to ISA Journal.

Report on the Employment Register, Fourth Annual Conference of the ISA, St. Louis, Mo., Sept. 12-16, 1949

The Employment Register was operated by the following committee of the St. Louis Section: Wm. K. Volz, Chairman, F. E. Head, W. J. Katt, J. Opie, C. P. Orr, W. Rosenbaum, C. Werstler, H. Zeffren, E. W. Zurow.

	AT OPENING Sept. 12	AT CLOSING Sept. 16
Positions Open	8	17
Instrument Engineer applications for positions on file	44	57
Instrument Mechanic applications for positions on file	53	62
Prospective Employers who examined files for qualified instrument men		16
Interviews arranged between prospective employers and applicants		15

The relative minor employment activity may be considered due to the following:

1. Applicants were limited to members only; in previous years any instrument man (members and non-members) were eligible for consideration by the Register.

2. The current decrease in business activity may have prevented many members from attending and making application in person.

3. The current decrease in business activity may have been responsible for the relatively low number of open positions.

The facilities provided by the Society for the Employment Register were quite adequate consisting of an employment desk operated by the Committee and two interview booths for review of files by prospective employers, and for interviews and consultations.

WM. K. VOLZ, *Chairman*
Employment Committee,
St. Louis Section

NOTE: During the two weeks following the Conference and Exhibit, 62 mailed applications were received from members for the positions posted at the Employment Register. Apparently members who attended took home a list of the open positions for their less fortunate member friends. This bears out the contention of Mr. Volz that decrease in business activity may have prevented many interested members from attending.

C. F. GOLDCAMP, *Chairman*
National Employment Committee

Light Rays Can Be Tools*

By ALLEN R. FULTZ†

THE supreme precision of a beam of light is an old story. It is straight — regardless of the distance it travels. It exerts no pressure on the objects it falls upon. It does not wear. And it is exact — furnishing the universal standard for all measurement.

But if these properties of light are themselves an old story, their applications in industry constitute a new one. For not until light has been harnessed by optics, are these properties useful as a means of gaging in the shop or plant. Yet once harnessed light rays can be tools — can, for example, measure the angle between two related surfaces to an accuracy of less than one second of arc, measure a rise of .002 inch in a distance of 30 yards, or magnify an object to a degree where one operator can check 18 separate dimensions to tolerance of .0005 inch at a rate of 280 parts an hour.

Each of these applications apply familiar principles of light. In one case a beam of light is used as a perfectly straight line of reference. In another, this beam is put to work by applying the simple geometric principle that the angle of reflection equals the angle of incidence. In the third, advantage is taken of the ability of optics to change scale. Which property is pertinent, depends on the product in manufacture, how it is made, how it is inspected, and how it is used.

However, this does not mean that a large research program in optics is a prerequisite of using light as an industrial tool. Certain basic optical designs are applicable to the majority of industrial uses because of their universality and their versatility. These fall in three major classifications.

a. Autocollimation — in which a beam of light is reflected back on itself from a reference surface on the work, for checking the angle between two planes to any desired accuracy, however, far separated.
b. Telescopic alignment — employing such devices as double-ended telescopes and divided-aperature objectives, for establishing by absolute methods a line of sight in fixed relation to a plane and then measuring displacements of distant targets from it in ten-thousandths of an inch.
c. Projection of silhouettes and illuminated surfaces to a screen where they can be measured and examined at any magnification, by eye, by photocell, or by photography.

Instruments falling under the classification of autocollimation are for the measurement of angle. Their basic principle is simple as a good gage should be. Everyone knows that to see his reflection in a mirror he must stand directly in front of it and this knowledge is the basic premise of the autocollimator. Yet, the angular tolerances practical with instruments in this group, may be evaluated by the fact that one second of arc is equal to a rise of .001 inch in a distance of 17 feet or a rise of one inch in a distance of about 3½ miles.

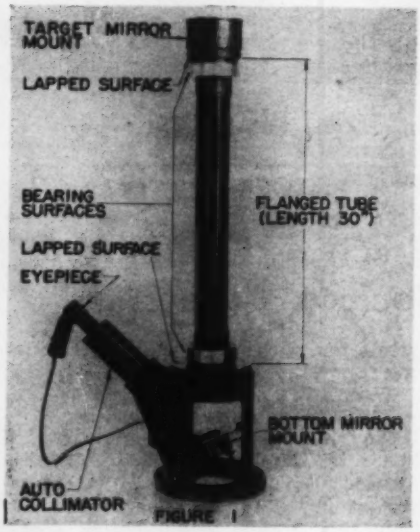


FIGURE 1

Fig. 1 illustrates an instrument of this type to check flange faces on each end of a tube, regardless of length, for parallelism. The tolerance governing this parallelism was 30 seconds of arc. Stated in another way, if the lower flange was resting on a surface plate and the upper flange was indicated across its diameter, the permissible tip from one side to the other would amount to .0006 inch. The residual error in the autocollimator was in the order of 5 seconds of arc, and parts were, therefore, accepted or rejected on a variation of 25 seconds of arc.

Fig. 2 is a cross-sectional view of the autocollimator and target mirror mounts. The top face of the instrument has been lapped to a flat surface. Likewise, the bottom face of the target mirror mount is a flat lapped surface. The work piece has been removed and the lapped surface of the target mirror mount is in direct contact with the lapped surface of the instrument. Through the eyepiece, an observer sees a magnified image of a reticle which for the moment can be considered as a cross-line scribed on a clear glass disc. The light source just below the eyepiece projects, with the aid of a half-silvered mirror, an image of the reticle through the telescope lens. This projected image strikes the bottom mirror and is directed upward through the top face of the instrument in a direction perpendicular to the lapped surface.

The target mirror is then adjusted in its mount until the image of the reticle is reflected exactly on itself returning into the telescope lens. An operator looking through the eyepiece will see only the actual reticle, the image returning from the target mirror being obscured by the reticle. Now, if the target mirror is tipped the image will not coincide with the reticle and the amount of tip can be read directly if the reticle has been provided with suitable graduations.

The operation of inspecting the flanged tube is simply to place one end on the top surface of the instrument and set the target on top of the tube, reading the deviation of the reticle and making certain it is within the specified tolerance. Since no skill or special training is required on the part of the operator, this method of performing a difficult inspection has proved far more satisfactory than the usual snap gage or the more general surface plate and height gage methods of inspecting such parts.

This instrument illustrates some of the superlative advantages of light as a measuring medium. There is no wear in a light beam — it exerts no pressure on the work — and it is not subject to

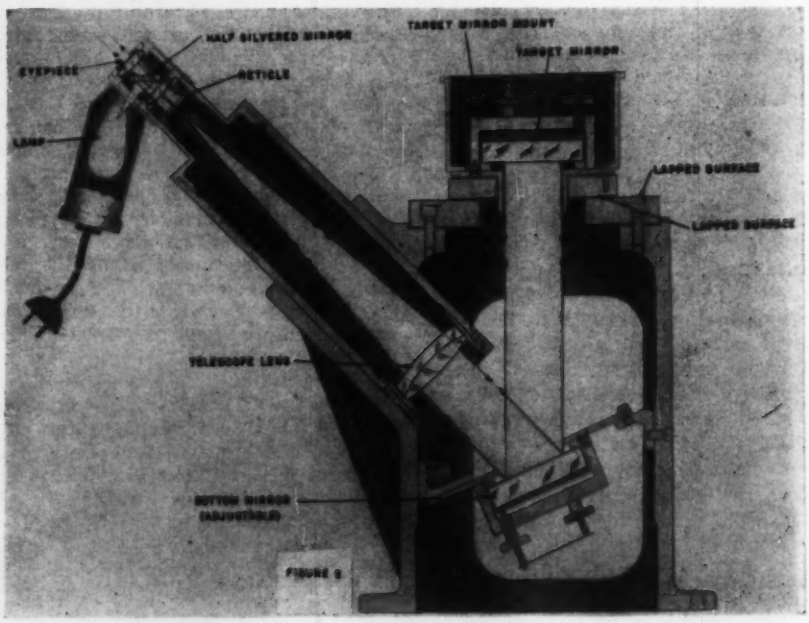
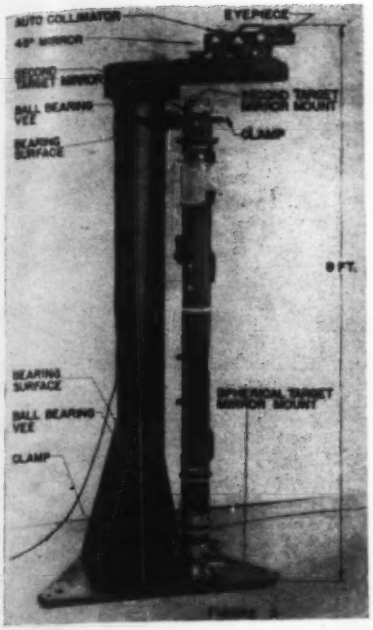


FIGURE 2

*Presented at the Fourth Annual Conference of the Instrument Society of America, Sept. 12-16, 1949, St. Louis, Mo.

Note:—Statements and opinions advanced in papers are to be understood as individual expressions of the authors and not those of the Society.

†Chief Tool Engineer, Hawk-Eye Division, Eastman Kodak Company, Rochester, N. Y.



variations from bending or temperature effects. Furthermore, autocollimation is totally insensitive to distance. Since the telescope lens is focused on infinity the beam emerging from the telescope lens is parallel light. Hence it can be sent over any distance without any change in the image of the reticle. The angular deviation of the light beam is the same whether the two surfaces to be measured are only a fraction of an inch apart or separated by many feet. Had the tube been a solid shaft, the light beam could have just as easily been brought up the outside with a target mirror mount designed to offset the beam.

Another important advantage in this particular instrument is that it is self-checking at the convenience of the operator. With the two lapped surfaces in contact the instrument should read zero.

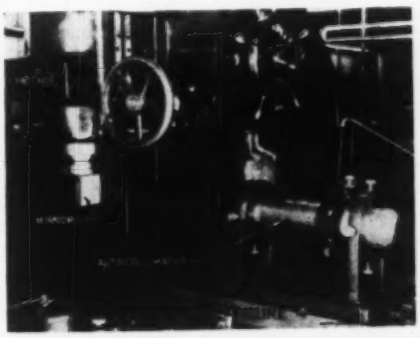
In addition to checking the parallelism of the flange shown on the tube in Figure 1, autocollimation can provide a check of the angular relationship existing between the two bearing surfaces and the ends of the tube. When the tube is raised from the instrument and located in relation to the light beam by two vees in which the bearings rest, the target mirror will then be deflected by the angular error between the bearings and the upper end of the tube. This error can be read directly in terms of angle. To check the bottom end of the tube it could be reversed in the vees and checked. A faster method, however, would be to have a second target mirror with a lapped surface above the mirror which can be clamped on the lower end of the tube and interrupt the beam at that point.

Fig. 3 shows an actual instrument used to inspect a tube of this type approximately 7 feet long. The problem was to check the parallelism of both ends of the tube in relation to each other and also in relation to two cylindrical bearing surfaces. The bottom end of the tube was placed in a support on which was mounted a mirror. This support was carried on a spherical bearing so that it was free to swivel in any direction. The bearing surfaces were then clamped into two ball bearing vees.

The autocollimator at the top of the instrument is in principle like that just described, except that a 45 degree mirror has been attached at the telescope end to direct the beam downward. The bottom mirror naturally assumed a position parallel to the plane of the lower end of the tube and thus the error between the end of the tube and bearings could be read directly. Rotating the tube in the ball bearing vees gave an indication of the lack of concentricity between the two bearings since this would introduce an added error.

To check the upper end of the tube a second target mirror mount having a mirror mounted on its upper face was simply placed on top of the tube intercepting the light beam at that point. In this manner, the same inspection could be made of the upper end of the tube.

The specified tolerance for parallelism between the ends of the tube was 30 seconds of arc or .00014" per inch of diameter. The diameter of the tube was approximately 3⅞ inches. The tilt between the two faces could, therefore, amount to a total of .00044 inches. The tolerance for perpendicularity between the ends and the bearings was 40 seconds of arc. The actual height of this fixture is about 8 feet; it illustrates the point that autocollimation is insensitive to distance.



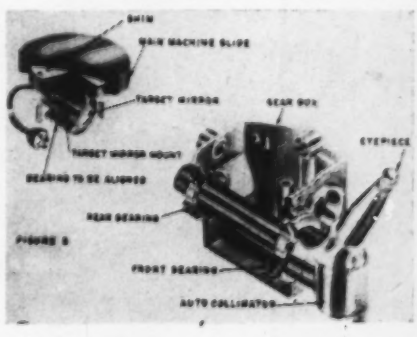
There are instances in which it is more desirable to take the autocollimator to the work. Fig. 4 shows an autocollimator mounted on a base for use as an optical square. The target mirror is mounted on an adapter which fits the spindle of a verticle milling machine. As set up in the illustration, the autocollimator is being used to check the squareness between the spindle bore and the table of the milling machine as the table is traversed. By other simple optical arrangements, the wobble of the spindle in relation to the table surface could be inspected. Still another problem might be to check the squareness of the traverse of the vertical spindle with relation to the horizontal machine table.

Naturally, the base instead of being a flat surface could be of any design to fit vee ways or bores as the alignment problem might require. The angular accuracy of this unit was 15 seconds of arc. However, rugged practical instruments for shop use can be built with a sensitivity of 5 seconds. This sensitivity can be increased if the precision of the job warrants the added cost of complexity of a suitable collimator. Instruments are now in use to measure angles to a tolerance of .3 of one second. This tolerance in lineal terms is a rise of .001 inch in a distance of about 50 feet or 1 inch in a distance of about 11 miles.

Fig. 5 illustrates a special instrument for use in manufacturing gear cutting machinery which is somewhat unique in that it combines the principles of both autocollimating and telescopic alignment. The job is to align two bearings in a gear box at the front of the machine with a third bearing of a distance of about 4 feet. This third bearing is mounted after various subassemblies of the machine have been built up, and variations in the tolerance of these subassemblies are absorbed by mounting the bearing on a shim to adjust it in vertical position. In the horizontal position, the base of the bearing is fitted in a circular recess and can be turned in this recess to align its axis with the axis of the bearings in the gear box. The problem was to determine the correct thickness of shim for the vertical position of the bearing and to rotate it in the circular recess until all three bearings were on the same axis. The tolerance requested was ± .001 inch for the correct shim thickness. Failure to obtain good alignment showed up as measurable errors in the gears being produced by the machine.

The mechanical method of doing this job was to place a shaft through all three bearings after inserting a shim of maximum thickness. Then by simply rotating the shaft as well as moving it axially through the bearings, the operator determined by feel whether as not the shim was correct. The shim was removed and ground thinner until the mechanic felt satisfied that the bearings were well enough aligned to insure good machine performance. An average of four hours' time was required to perform this assembly. However of more significance was the fact that if a machine assembled by a given operator at one time was inspected by him on the next day, he very often considered the assembly unsatisfactory which meant that little confidence could be placed in the actual accuracy of this operation.

To do the job optically, a target is placed in the bearing to be adjusted. This target consists of a mirror mounted on the end of a cylinder which accurately fits the bearing. A cross-line is cut through the silvered surface of the mirror and a small lamp behind the mirror serves to illuminate this cross-line. With the target in place a special autocollimator is mounted in the gear box. The bearing carrying the target can then be adjusted so that its axis is parallel to the axis of the bearings in the gear box, although not necessarily on the same line. The next problem is to measure the correct shim thickness to bring these two axes together. The autocollimator lamp is switched off and the one that illuminates the target cross-line is turned on. By slipping a cap in which is mounted an auxiliary lens over the end of the autocollimator it



becomes a telescope focused on the target crossline and with a reticle graduated in thousandths of an inch an observer can read the exact thickness of shim required to bring the axes of the bearings on the same line.

Instruments of this type undoubtedly offer an answer to many problems that exist in all kinds of machine construction and maintenance. The total inspection time is only a matter of 15 minutes or so and the adjustment of the target in the instrument is easily checked by placing both components in vee blocks on a surface plate. When aligned, the instrument — if in correct adjustment — will read zero.

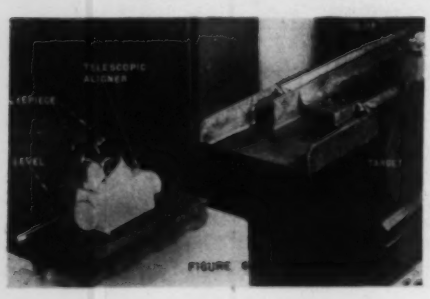
This instrument illustrates in a simple manner the idea of telescopic alignment. It is sufficiently accurate for the application described. However, where real precision over considerable distances is required, other optical combinations should be used. Fig. 6 shows an instrument called a telescopic aligner, which establishes by absolute methods a line of sight in fixed relation to a plane and will measure displacements from this line in 10 thousandths of an inch. It was designed in response to a request from several companies for an instrument of such accuracy to be used for the erection and inspection of long planer beds.

The beds of these machines sometimes are 100 feet in length and the guiding ways in the top of them must be straight and parallel within a few thousandths of an inch throughout their entire length. The common method of aligning these long beds is to stretch a piano wire along the side and observe the wire through a microscope mounted on a vee block moving in the vee way. This operation aligns the bed in the vertical plane. The horizontal alignment is made with a precision level, but one of the difficulties in using a level is that the center of long beds is usually raised appreciably to compensate for the sag that occurs when the heavy table and work is placed on the bed.

Obviously, these methods are cumbersome and subject to error from air currents and vibration. To make this alignment optically a target mounted on a vee block is placed in the vee way of the planer. The target itself is a simple illuminated slit. As the slit is moved up or down the indicator will register the amount of movement.

The aligner itself is placed on a small surface plate mounted on a pedestal of suitable height at a short distance from the end of the machine. The top of this surface plate is leveled to the precision required with sensitive levels. Three tungsten carbide pads on the bottom of the instrument rest on the surface plate.

These pads have been lapped into exact alignment with the optical line of sight. The optical axis of the instrument is now level and if the instrument is turned on the surface plate the line of sight describes a plane in space which is also level. If a distant target is placed in the line of sight then the distance from the target to the bed supporting it can be measured. The observer using the instrument only determines when the target is exactly on the line of sight. Consequently, the alignment process consists of adjusting a target vertically until the aligner operator reads zero. In other words, the reading is by the null method. Figuratively speaking, one might say that the target is hung on the optical axis of the aligner and the machine bed is then adjusted to contact the target support.



For alignment in the vertical plane, the target is indexed 90 degrees. A second slide and indicator on the target mount is used to measure deviations of the target from the optical axis of the aligner. Only a simple adjustment in the instrument itself is required when changing from the horizontal to the vertical plane.

Fig. 7 illustrates the basic optical principle of the aligner schematically. The objective lens looks at the target — here an illuminated vertical arrow — under two different conditions. In one case the lens has an unobstructed view and a beam of light from the target reaches the lens unhindered. This is represented by the lower beam in Fig. 7.

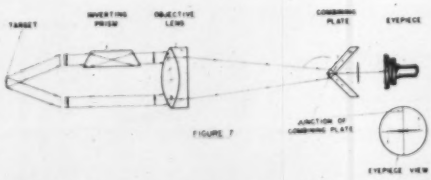


FIGURE 7

In the second case a beam of light from the target must first pass through an inverting prism before reaching the lens. Thus, the lens has two views of the target, one erect and one inverted.

Both of these beams are directed by the objective lens to a common focal point, but before reaching this point they pass through a combining plate. This element has the function of combining both beams on the lens axis without allowing them to overlap, as they would without the combining plate in place. Therefore, after passing through the combining plate the two arrowheads would contact each other. The combining plate is made up of two separate pieces of glass which are cemented together. The junction of these two glass plates forms a physical dividing surface between the two beams. An eyepiece view of this junction is a line dividing the field in the eyepiece in half and separating the two target images. As the target is displaced from the axis of the objective lens, the images in the eyepiece will move in opposite directions, because the motion of one is inverted. The displacement of the target appears in the eyepiece as a lack of coincidence between the two images. The only way that coincidence can be achieved is to return the target to the axis of the objective lens and the aligner therefore employs the well-known null method for reading.

It should be evident that as the target is moved to successive positions along the surface on which it rests, the displacement of the surface from the optical axis of the objective lens can be measured by measuring the distance the target must be moved in order to obtain image coincidence.

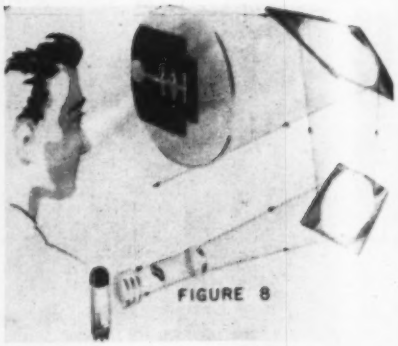


FIGURE 8

In the schematic drawing the target has been represented as an arrow so that its inversion could be readily recognized. In use, however, only a straight slit an inch or so in length is needed. When such a target is exactly on the optical axis the observer sees it as a bright line in the eyepiece field. Off axis, this bright line is split at the dividing line as one half moves up and the other down with the target's displacement.

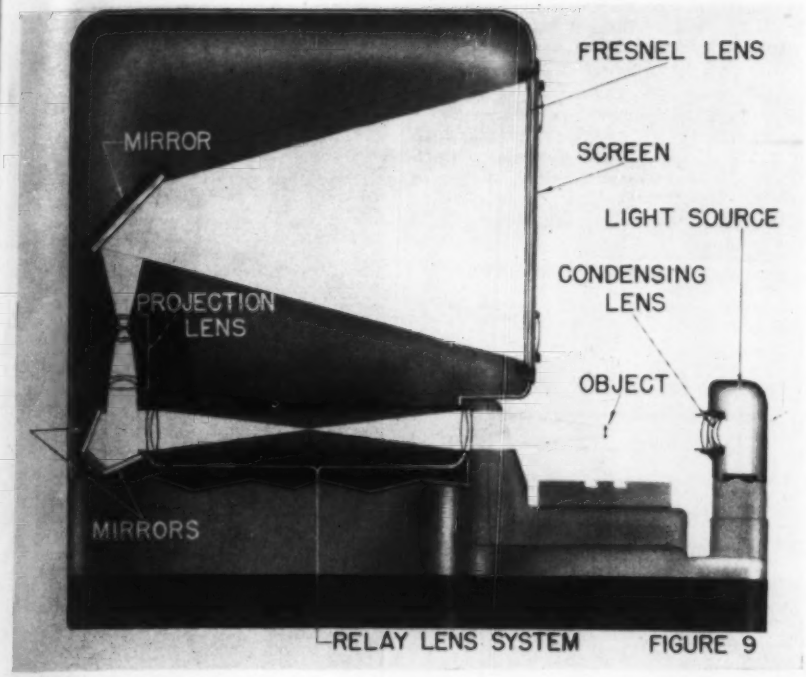
As indicated earlier, this instrument was designed with planers in mind. It can, undoubtedly, be applied to the solution of other problems of alignment involving heavy machine tools and other massive equipment ranging from steam turbines to airplane jigs. Its versatility stems from the fact that it establishes a truly straight line of reference and permits an observer to measure any deviation from this straight line.

The third major classification of optical instruments, that of projection, introduces the only use of optics for gaging mechanical components that has been employed to any extent in industrial inspection. However, the practically limitless applications of this tool to inspection problems have not been generally realized because projectors available to potential users have lacked the versatility of design necessary for wide application.

All contour projectors, as such instruments are usually called, work on the same basic principle. The outline or contour of the object being inspected is illuminated with a light source causing the object to cast a shadow. This shadow is magnified by a lens and projected to a screen where its magnified form can be examined visually or recorded photographically The selection of a contour projector, therefore, resolves itself to that one which first is most accurate in its optical performance, and second is most versatile to adapt projection gaging to the widest variety of work.

The four basic elements for contour projection are the light source, object, lens, and screen. Fig. 8 shows these basic elements combined into an industrial projector. A condensing lens directs the light in a parallel beam, and two mirrors are utilized to fold up the system and place the screen in a convenient position for the operator.

However, if this simple system is supplemented with several unique elements, the versatility of the instrument may be greatly increased. The first of these unique elements (Fig. 9) is a relay lens system. Not until now has such a system been available in projection. One of its contributions is to increase the clearance between the object or work piece and the first lens of the optical system to a full 8 inches. This clearance remains constant regardless



RELAY LENS SYSTEM FIGURE 9

of the magnification selected, and provides plenty of room for large, awkward parts or for mounting efficient staging fixtures without interfering with operator freedom. The significance of this increased clearance can be better understood by pointing out that with the simple optical system used in (Fig. 8) the greatest clearance available would have been about 2½ inches at low magnifications. As the magnification was increased this clearance would have decreased accordingly, becoming approximately ½ inch at a magnification of 100 times.

The convenience of the large clearances which are afforded by the relay system are shown in a gear and cam assembly (Fig. 10) set up for inspection by contour projection.

The relay lens system (Fig. 9) also fulfills a second important function. It transfers an image of the object at a magnification of 1:1 to the rear of the instrument where projection lenses of any desired magnification can be mounted inside a dust-tight cabinet. For the utmost in operator convenience the projector can have a turret carrying five projection lenses from 10X to 62.5X, any of which can be indexed by a hand wheel at the front of the instrument (Fig. 10). An added innovation is that when the object is in focus for one magnification, it is also in focus when the turret is indexed to projection lens of other powers.

A third function of the relay lens, (Fig. 9) together with the twin-mirrors at the rear of it and a third mirror, is to provide a right-reading, erect image on the screen. The twin mirrors help to further reduce the bulk of the instrument while redirecting the light beam upward through the projection lens. This beam is then reflected from the mirror at the top of the instrument to the projection screen.

Immediately behind the ground glass screen is inserted a second special optical element — a fresnel lens. This element actually increases the screen brightness by a factor of at least ten times. In addition, it distributes the illumination evenly over the entire screen area. The usual disturbing "hot spot" is completely eliminated.

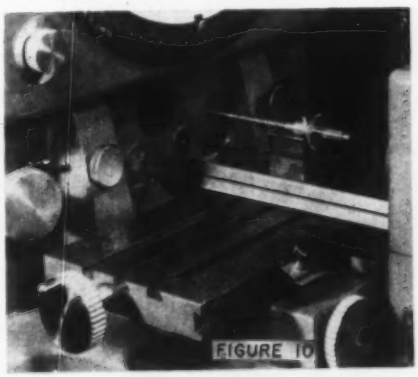


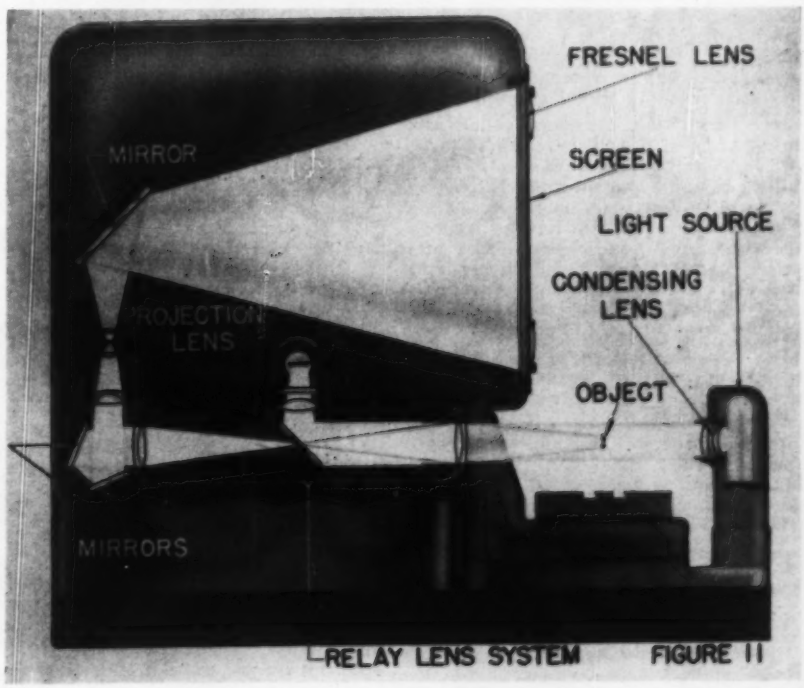
FIGURE 10

The reason for increasing screen brightness is that the shadow outline should contrast strongly with the illuminated portions of the screen, to assist an operator in making quick, accurate measurements or comparisons. Since the object is usually opaque, the only way contrast can be improved is to increase screen brightness. This is done with a fresnel lens by concentrating the cone of light coming from the projection lens into a cylindrical beam approximately the diameter of the screen and directed at the operator. With such a system the projector need not be located in a dark corner or be surrounded by hoods or curtains but may be placed in any desired location in the manufacturing line.

Thus far projection has been described in only one aspect, as the projection of the external contour or shadow of an object. There is still another kind of projection — surface reflection — the type of projection embodied in a simple mirror. Here the surrounding light is reflected from one's face into the mirror and returns to the eyes.

There are many instances in which sections of a work piece may be recessed or obstructed, or measurements of details on a surface must be made. Examples of such details are punches, type face, all kinds of blind holes or cavities, and embossings. In such cases the surface can itself be projected as a bright image in contrast with the usual shadow image.

Here again, the use of a relay lens system affords a unique opportunity for obtaining maximum illumination of a surface under study. By inserting an elliptical mirror in the relay lens system (Fig. 11) light from a 1000 watt lamp is directed through the front relay lens on to the object. The object reflects this light back into the lens but since the reflected image converges, a hole is provided in the mirror through which the light forming this image passes. This image is then directed by the regular optical system on to the screen. The brilliance at the screen is determined both by the amount of light



RELAY LENS SYSTEM FIGURE 11

focused on the object and by the reflectance of the object.

By using an intense 1000 watt source it is possible to actually project black Bakelite molded parts — about as difficult an object as can be imagined.

Still another interesting attachment for projection permits inspecting thin or flat parts by simply placing them on a glass stage which is raised or lowered until the part is in focus. For this a lamphouse containing a light source and a condensing lens may be attached to the top of the projector housing, as in Fig. 12. The stage, with a glass insert in the top, is mounted on the work table over a 45 degree mirror supported by a bracket attached to the front of the instrument. When a part is placed on the stage the beam from the lamphouse projects its shadow through the glass stage and on to the mirror, which redirects the light to the front relay lens.

This attachment is equally adaptable to surface illumination. In this case the beam coming from the first relay lens strikes the 45 degree mirror and is turned upward, strikes the object, and is reflected back on itself exactly as with horizontal projection. Likewise, both the vertical light source and the surface reflection illumination may be used simultaneously if the contour and the surface of an object are to be viewed at the same time.

Thus, it is possible to design a contour projector (Fig. 13) which with simple and inexpensive attachments can be converted into a dual-purpose inspection instrument. The advantages of both horizontal and vertical projection — either of contour or surfaces — are available without the necessity of providing two specialized projectors.

Here again the versatility of the science of optics is in evidence, incorporating in a single system elements which do not one, or two, or perhaps a half-dozen jobs, but numerous tasks of varying complexity. As in the case of autocollimation and of alignment, light

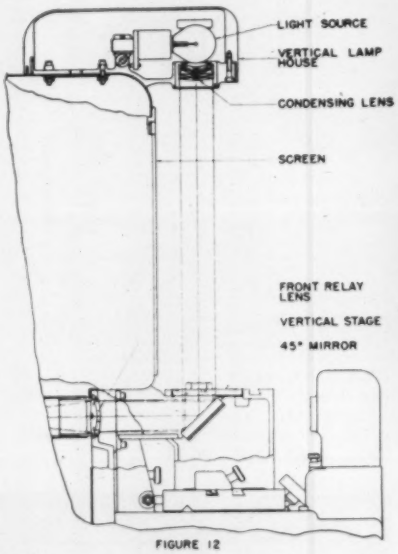


FIGURE 12

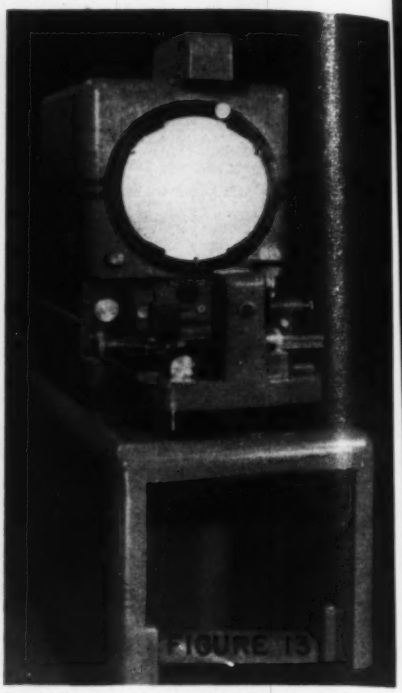


FIGURE 13

has been harnessed as a tool, easily used and offering all the inherent advantages of a precise, pressureless, and predictable gaging element.

Process Control By Graphic Panel*

By DAVID M. BOYD, Jr.†

THE instrumentation of oil refineries has passed through three distinct stages and now appears to be approaching a fourth stage.

The early refining units were batch shell stills in which the crude oil was heated to a temperature high enough to boil out the gasoline and kerosene fraction. These products were sold by their specific gravities and therefore the operation of the unit was monitored by the operator taking a sample and checking it with a hydrometer to determine the cut point of a given fraction.

As competition became keener and the capacity of the units became larger the shell stills were replaced by continuous columns and the specific gravity alone was no longer an adequate means of specifying a product. Boiling ranges, initial and end point, became the primary means of specifying a product. Temperatures and pressures replaced the hydrometer as the primary means of control.

The instrumentation of the units at the end of this first stage of development consisted of thermometers and pressure gauges.

As management became more cost-conscious about the operation of the plant, recorders were added to the unit and finally, controllers were developed and installed which gave closer control of the operation of the unit than was obtained by manual operation. These instruments of this second stage of development were locally mounted, as were those of the first stage.

In the meantime there were process changes that required higher temperatures and pressures. Closer control of these temperatures and pressures was required because in many cases the yields were directly related to these variables. It became more and more desirable to locate the records centrally in order to give the operators a clearer picture of the condition of the unit at any given time.

The control panel of this third stage started out in one corner of the pump room and as the units became more complicated and the instruments and controls became more numerous, the board expanded until it required a building all to itself.

It was during this stage of development that we entered into the tremendous war construction program of 100 octane gasoline and synthetic rubber plants. These plants were much more complicated than the usual plant up to

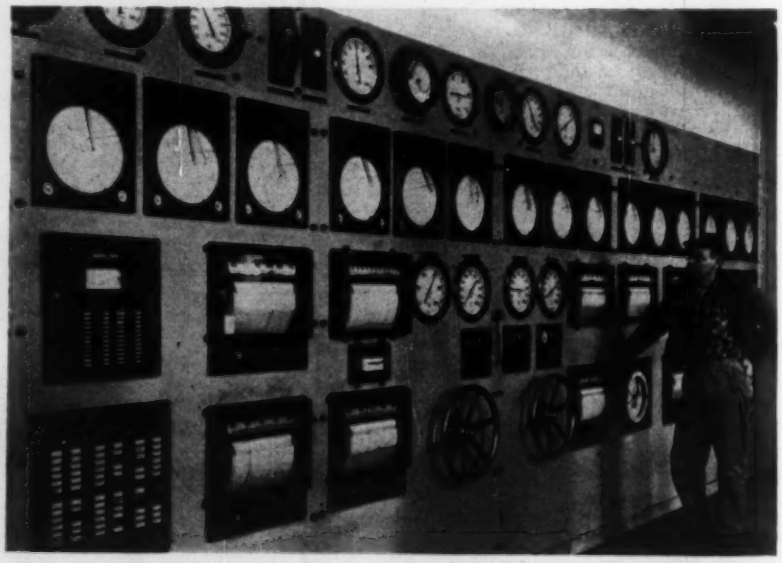


Fig. 1. Old Style Panel.

*Presented at the Fourth Annual Conference of the Instrument Society of America, Sept. 12-16, 1949, St. Louis, Mo.

†Universal Oil Products Company, Chicago, Ill.

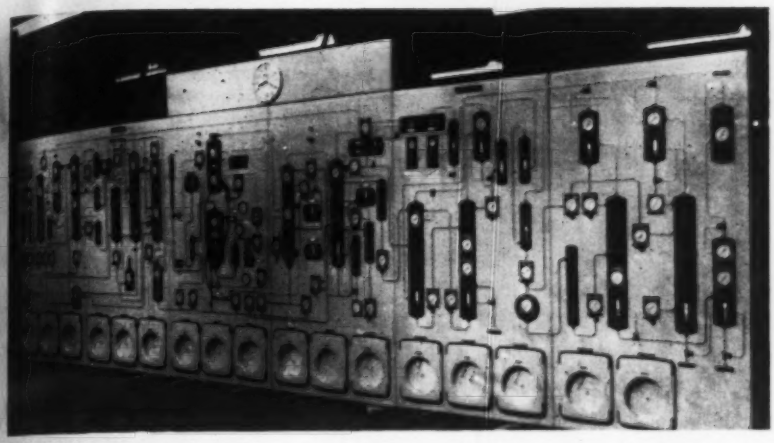


Fig. 2. New Graphic Panel containing about 75 Controllers and 30 Indicators in the same panel space as the old panel.

this time, with the result that the control rooms were very impressive indeed. Control panels of 100 and 150 feet were not uncommon. The long rows of instruments, all looking very similar in appearance, were confusing to new operators even though they carried name plates on their cases. Probably more than one plant superintendent considered putting roller skates on his control room men.

Another problem that developed with this type of centralized control room, and that caused concern on the part of some instrument engineers, was the amount of transmission lag that was introduced into the control system. The plants had not only grown more complicated, but had grown physically in the area covered. This growth meant longer transmission lines and as a result, a certain amount of lag was introduced into the control system. This lag was not too serious in temperature, gas, pressure, or some level control problems, but was found to give trouble on liquid flow control problems, especially where the mercurvless type of flow transmitters was used.

These drawbacks to the centralized control room coupled with the inherent operational advantages of having all of the information centralized in one room, have caused a new type of control system to be considered which may well be the fourth stage in the development.

For a discussion of this type of control room it would be well to take as an example the Rock Island Refining Company at Indianapolis, which is the first refinery using this system, to see what the problems were that caused the change to it.

This refinery operated a combined crude and thermal cracking unit and had a gas concentration and poly unit connected with it. The new construction program called for the revamp of the thermal cracking unit, a feed preparation section, the addition of a fluid catalytic cracking unit and facilities for the production of liquified petroleum gas.

It was desired to use the existing control room for the new facilities, even though they would be about 300 feet away, in order to centralize the operation of the whole refinery. This, coupled with the fact that mercuryless flow transmitters were to be used on the new unit, called for the consideration of pneumatic set locally mounted controllers.

A check of the number of instruments required for the new facilities showed that the space available in the existing control room was not sufficient to hold a conventional type of instrument panel even though the whole north side of the control room were used. The existing panel covered the south wall and most of the north wall was used for light, ventilation, and a door.

All of these considerations seemed to point to the use of a new type of control system, in which the controllers would be locally mounted and would require a minimum of board space. The graphic panel type of system seemed to hold promise with its smaller type of instruments and the pneumatic set controllers where required.

A rough design of a graphic panel was made and shown to the owner of the refinery. He agreed to try it out on his new unit because he felt it would have a distinct advantage for him. This would be in the ease of training the operators on the handling of the new unit, as the flow sheet would be in front of them at all times. The owner, an engineer experienced in refinery design, seemed to like the idea quite well; he called again the next week and asked that the instrumentation of this existing plant be converted to the new system. This meant buying all new instruments.

He felt that this would be a wise investment because he found that it took him years to train an operator in his refinery and he felt that having the instruments incorporated in a flow sheet of the plant in front of the operator would speed up his training program and lessen the possibilities of having the unit upset. He also wanted to use only his existing panel space and not lose any light or ventilation from the north wall.

This was like changing the rules in the middle of the game, but a rough layout of the panel showed that it could be made to fit into the available space. Thus, it was decided to go ahead with the graphic panel board containing the whole refinery on one panel board 25 feet long. Then began the problem of working out the details.

Controller Location

One of the first points to be decided in the design of the panel was where to mount the controllers, since the field-mounted controllers required four runs of tubing as against two runs for the board-mounted controllers. The 300-foot transmission distance is the bulk of the lag in the flow control system because mercuryless flow transmitters were being used. Tests were carried out using two different force-balanced flow transmitters, two different controllers, and two different valves and positioners. These were used to control a small flow of water from a plant water line. Various lengths of tubing were used in the transmission and controller lines to give the effect of moving the controller to the control board.

With the installation a direct relationship was found to exist between the throttling range required for stability and the distance from the controller to the process. The throttling

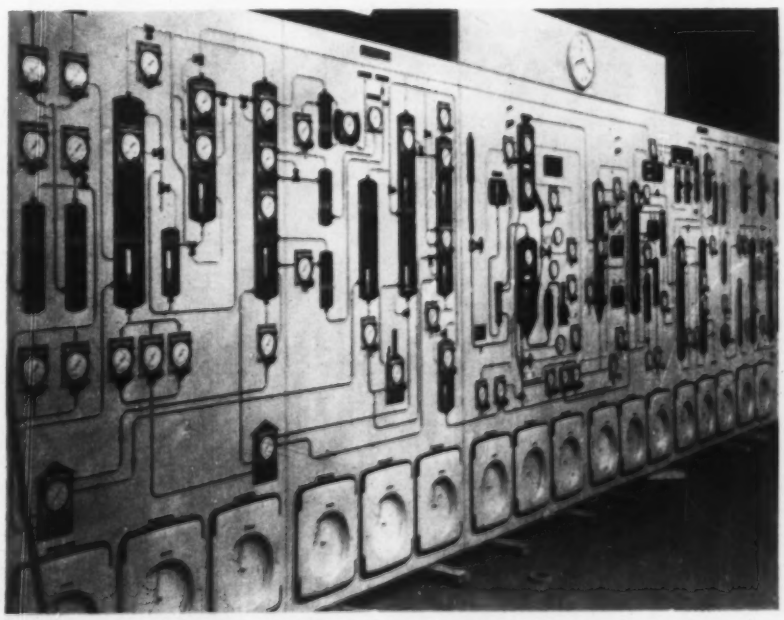


Fig. 3. Full view of panel showing flow plan arrangement. Units shown are left to right: Crude Unit, Catalytic Cracking Unit, Fractionation Unit, Gas Concentration Unit, Catalytic Polymerization Unit, and Liquified Petroleum Gas Unit.

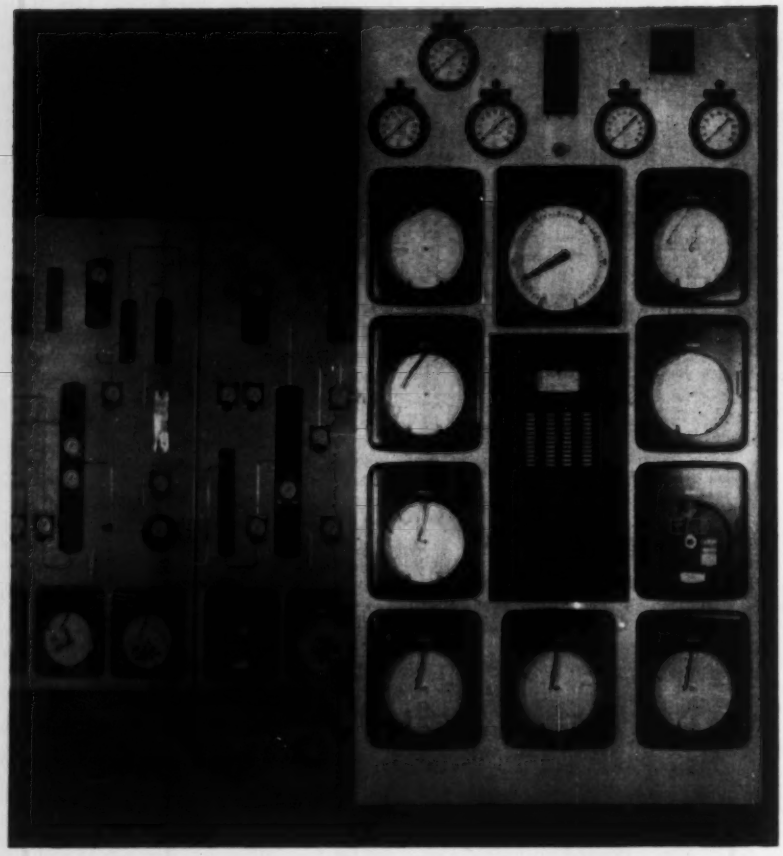


Fig. 4. Recorder Panel for the Indicating Controller on the Graphic Panel.

range varied from 75 percent at 10 feet to 500 percent at 300 feet transmission distance. The reset rate setting was .2 minute at 10 feet which was the fastest reset rate obtainable at this time on conventional controllers. When the transmission distance reached 300 feet the reset rate was .5 minute. All of these figures are interesting but the main factor is the actual performance of the controllers at 10 feet transmission distance and at 300 feet transmission distance. For a given upset, the area under the recovery curve of the controller at 300 feet was a matter of a hundred times greater than the area under the recovery curve of the controller at 10 feet.

The throttling range of the controller located at the 300-foot distance could be reduced to any desired value by restricting the flow into the receiver element by means of a dampening device, but only at the sacrifice of reset rates and accuracy of measurement. The net control was not found to be materially improved by the addition of the restriction to the board-mounted controller, even though a better apparent flow record might be obtained.

It is rather interesting to observe that none of the conventional pneumatically operated controllers that are in use today in oil refineries are really of a completely satisfactory design for the control of flow, in that they are proportional band controllers instead of pure proportional speed floating action. The reset rates that are available on the conventional controllers are about ten times slower than can be used with locally mounted controllers and mercuryless flow transmitters. Probably the main reason that the available proportional speed floating controllers are not used is that they are too bulky and expensive. A market appears for a small, simple, pre-engineered proportional speed floating controller, preferably one that could be mounted right on the control valve. Flow controllers account for 50 percent of the controllers used in refineries and this should provide an interesting market for some manufacturer.

Records

In designing this panel, a considerable amount of thought was given to the question of which points to record. When the owner of the plant was consulted, he indicated that he was not interested in permanent records of all of the controllers, because these data are recorded on the operator's log sheet every hour or two and the records are not consulted very often after they have been removed from the instrument except for accounting purposes and to show temperature trends.

Five pneumatic recorders were provided, each of which contained four pens, giving twenty recorder points in all for the seventy-six controllers and approximately thirty indicators that were used on this plant. These recorders are all 3- to 15-pound receivers and are provided with snap couplings so that they can be plugged into any of the controllers or indicators on the board that the operator desires to record. The temperature transmitters used on this panel were of the recording type, so that they gave continuous records of the temperature trends at all times.

Panel Layout

In laying out the flow plan on the

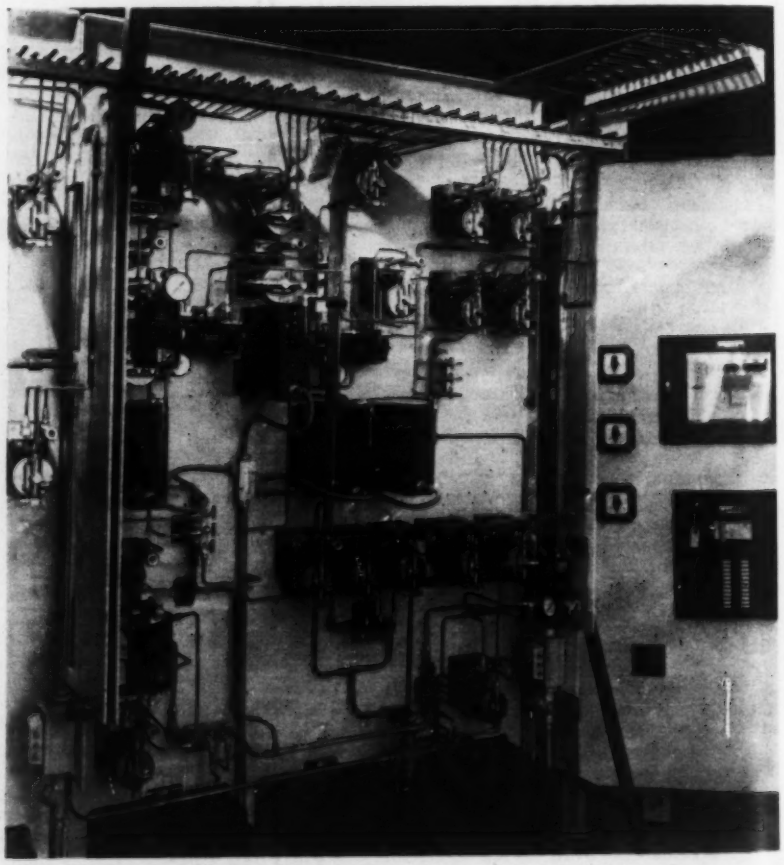


Fig. 5. Rear view of the Graphic Panel.

panel every effort was made to keep it as simple as possible. Only major pieces of equipment and process flow lines are shown, such as towers, reactors, and heaters. Heat exchangers and pumps are not shown on the panel, because it was felt that they would result in unnecessary complications in the design of the panel. It was not intended to make the panel a detailed flow sheet of the plant. The purpose is to give the operator a quick generalized view of his process so that he can more readily visualize the part each controller plays in the process, without carrying the details to such an extent that it becomes a toy.

Acknowledgment

I wish to express my appreciation to Mr. L. E. Winkler of the Rock Island Refining Company for allowing us to use the data obtained in his plant and to L. E. Stewart of Universal Oil Products Company for his help in running the flow tests.

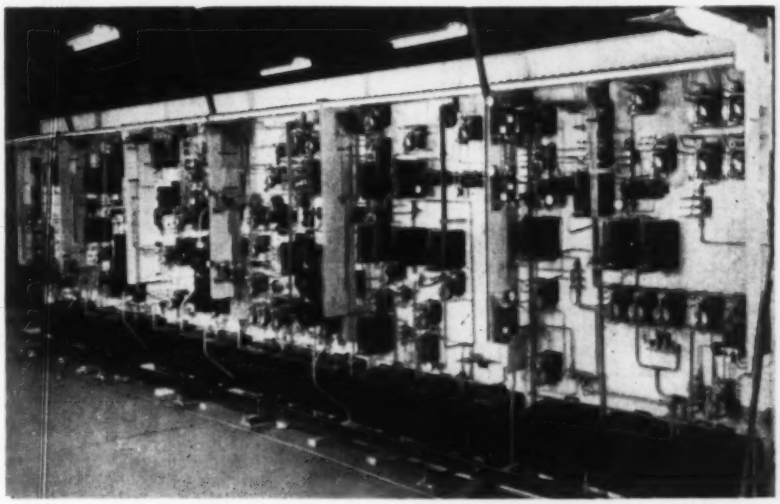


Fig. 6. Rear view of new Graphic Panel showing tubing connections on top of panel. Large black instruments at bottom are temperature transmitters. Medium sized instruments at middle of panel are the level indicators.

Instrument Shop Tools*

By FRANCIS S. BECKER†

THE object of this paper is to outline the quantity and variety of tools necessary to successfully carry on the mechanical maintenance of an Instrument Department in any continuous process industry.

The quantity and variety of tools in the ideally equipped instrument shop varies somewhat with the size of the plant and the type of equipment the shop is called upon to service. However, for our discussion, we will assume a shop that is to service the average oil refinery of 100,000 bbls./day capacity.

An oil refinery of this size may have an Instrument Department Personnel of approximately 60 men actively engaged in servicing instrument equipment. Although some refineries of this size divide their plant into areas with a separate shop to service each area, we will assume that this is a compact refinery being serviced from one central instrument shop.

We will, therefore, assume that our instrument shop is of sufficient physical dimensions that our force of 60 instrument men can work from this shop and all tools subsequently enumerated and described are for a shop of these dimensions.

In discussing shop tools of any kind we are apt to think primarily of power tools. However, in any instrument shop there are quite a number of hand tools necessary, some of them of a very special nature. Investigation has brought out the fact that the cost of these hand tools exceeds, or at least equals, the cost of the power tools. In view of the quantity and cost of these hand tools, I feel that it is important to discuss them at some length.

One of the most common of hand tools found in any shop is the vise. In my opinion the following different types and sizes are needed:

2—6″ machinists vises for heavy duty valve and meter work.
30—2½″ machinists vises, or one for every two instrument men, preferably mounted in the middle of the bench space alloted to two instrument men.
6—Portable pipe vises, or one for every ten instrument men.
2—Drill press vises and at least 2 jewelers vises for small delicate work.

Taps and dies are another common but very important hand tool in any shop. It has been my experience that the minimum quantity and variety needed are as follows:

6—Complete sets of pipe dies and taps from ⅛″ up to 1″, or one set for every 10 instrument men.
4—Complete sets of bolt and machine screw taps and dies up to ½″ in both standard and S.A.E. threads.

In addition to these are numerous miscellaneous hand tools as follows:

6—Sets of copper tubing flaring tools.
6—Sets of copper tubing bending tools.
2—Sets of pipe bending tools up to 1″ pipe.
6—Sets of hole punches.
6—Sets of gasket cutters.
3—Pairs of straight and curved cutting tin shears.
3—Blow torches (gasoline).
6—Electric soldering irons in various sizes.
6—Rawhide mallets.
3—Sets of depth gauges.
2—Sets of inside and outside micrometers.
3—Acetylene welding outfits.
3—Sets of number and letter stamps.
3—Complete sets of socket wrenches.
3—Complete sets of open end wrenches.
1—8 ft. stepladder.
1—4 ft. stepladder.
2—30 ft. extension ladders.
6—Various weight sledge hammers.
6—Wire brushes.
6—Complete sets of packing tools.
12—Large Stillson wrenches from 24″ to 48″.
6—Pairs of wedges for driving flanges apart.

There are also many special hand tools necessary in any instrument shop.

Every shop should be equipped with at least 3 sets of so-called non-sparking tools for hazardous locations. These sets should include open end wrenches, hammers, Stillson wrenches, screw-drivers and wedges.

3 or 4 special wrenches for removing valve seats.

2 or 3 special tools for removing gauge pointers.

Special wrenches for removing parts of meters.

At first glance the quantity of some of these hand tools may seem excessive, but one big plant general shutdown, when all of these tools might be in service will more than pay for the cost of duplicate tools in maintenance time saved.

Each shop should also have one electric welding outfit, one small metal break for bending sheet metal to fabricate special instruments, 2—¼ ton chain hoists and 4 small rubber tired carts for hauling valves and meters from location to the shop for repairs.

In addition to the hand tools listed above, It is my belief that every shop should be equipped with the following power tools:

1—Pedestal drill press up to ½″ capacity for general use.
1—Bench drill press up to ¼″ capacity for light precision work.
1—Jig saw.
1—6″ bench grinder.
1—6″ buffing wheel equipped with wire and cloth wheels.
1—Toolmakers lathe or equivalent. This item is probably the most expensive single piece of equipment in an instrument shop and careful study should be made of the requirements of any particular shop before deciding on the type of lathe to be purchased. A good lathe of this type will cost anywhere from $1,000.00 to $5,000.00. There are small lathes on the market of the type built for the home work shop which cost from $100.00 to $300.00, but unless it is a very small shop and price is of the utmost importance they are not recommended for instrument shop use. Whether you spend $1,000.00 or $5,000.00 for your lathe depends on the size of the shop and the quantity of work expected to be produced on it to

*Presented at the Fourth Annual Conference of the Instrument Society of America, September 12-16, 1949, St. Louis, Mo.

†Sun Oil Company, Marcus Hook, Pa.

justify the amount of money you have invested in it. For the average shop the expenditure of up to $2,000.00 for a lathe is well justified. In our opinion a lathe is a very important instrument shop tool and in a years time will more than pay for its original cost. It has been our experience that the maintenance machine shops in most industries have only one lathe of this type and it is usually in operation 24 hours a day taking care of general plant maintenance so that it is practically impossible to get any instrument department work done on it. Another advantage in having a lathe in an instrument shop is that the operator either is an instrument mechanic or is familiar with instrument work and emergency lathe work can be greatly expedited by not having to make detailed drawings of the work to be done.

An electric lathe grinder should be included in the lathe accessories. This tool is very essential in producing highly polished surfaces and also in working with Stellite and other materials which are too hard to machine with a tool.

Three or four sets of drills should be stocked, both for the lathe and for drill press work. These should be in the number sizes from #1 to #60 and in the fractional inch sizes from 1/16" to ½".

In addition to the larger power tools we have already discussed, each shop should be equipped with the following portable power tools:

2—¼" pistol grip portable electric drills.
2—½" portable electric drills.
1—¼" pistol grip portable pneumatic drill for use in hazardous areas where electrically operated equipment would be prohibited.
1—½" portable pneumatic drill for the same purpose.
2—Pneumatic impact guns for tightening and loosening orifice flange and valve flange bolts.
2—Paint spray guns.
1—Power hack saw.
1—Hand operated hydraulic pump for hydrostatic tests.

If any of you might be interested the cost of tooling a shop of this size in the manner we have discussed would be about $2,550.00 for hand tools and $2,665.00 for power tools, or a total of $5,215.00.

This figure is based on spending about $1,600.00 for a lathe, however if the quantity and quality of work to be handled by the shop warranted a $5,000.00 lathe the total cost of tooling might be increased to as much as $10,000.00 on the assumption that all power and hand tools would also be of higher quality and price.

In conclusion I would like to point out that the sum of $5,215.00 or even $10,000.00 is a very small amount to properly tool an instrument shop of this size when one considers the fact that this shop will be servicing instrument equipment worth about one million dollars. This money spent in tools is well justified when one also considers the time saved in man hours and the better morale of the men in the instrument department when they have the proper tools to work with.

We Want Blood

The following editorial by W. G. Moline, Editor of *The Detroit Recorder* appeared in the September issue of that periodical.

In May 1947 there appeared in this organ a provocative article under the title "Let George Do It"* The article was well worded and timely, in fact it provoked the writer into getting off the cushion and giving "George" a hand.

But now that we are approaching the 1950 season it is apparent that many of our members are content with "letting George do it," or perhaps just content. Let's pause for a moment and consider our new Council—same old faces, same old crew shuffled around a bit. Some are missing because they have gone on to better things, others grew weary of the grind and discontinued all effort.

It is this same condition that has wrecked empires and civilizations. In fact seventeen long years of the same old crew has come close to wrecking our once proud and free country.

WE WANT BLOOD—new blood that is. We need about twenty donors to give us a transfusion. Unless this transfusion is soon forthcoming, the Detroit Section will cease to exist from that same disease that has been responsible for the end of many people—Senile Decay.

WE WANT, NEED and MUST HAVE your ideas and opinions on the conduct of this Section. If you like it, tell us!! If it smells, tell us. But for crying out loud Man Those Pumps, WE WANT BLOOD.

(Signed) *Wallace G. Moline*

"LET GEORGE DO IT"

It has become a popular custom to "let George do it," in all sorts of ways. Yet satisfaction and fun go with active participation. The passive spectator lives a vicarious existance, with little or none of the rewards of personal activity. The participator is interested and alive, the spectator is perpetually bored and dissatisfied.

In our country, only a small percentage eligible to vote exercise their privilege. Yet one hears abundant criticism abut "the Government" as if it were some disembodied creature. Now I live in a small town fully equipped with town meetings, board meetings and caucuses. Being present at these meetings and participating in some of these small units of government, I have already begun to think in new ways. Where I said before "They are raising taxes" I now say "We are raising taxes," and I know why.

The same thing is true in our "INSTRUMENT SOCIETY," and in our SECTION. Problems that have come up have not always led to obvious answers. Yet the members participating in the discussions, of these problems, appreciate the compromises and understand the solutions. Every council meeting is open, every opinion is welcome, and anybody CAN participate; yet, there is a sizeable group of members who are just neutral, and another group just against whatever is done.

The vast world problems ahead are far too complicated for us to solve, but they are not too big for us to share. We can join in all the activities that touch on our lives, not just on the side lines but right in the middle of the scrap. It may be smart to be detached and cynical, but it is also deeply FUTILE. A little good faith, and a lot of work, the familiar ratios of inspiration and perspiration, have been the foundations for every worthwhile effort in the history of man.

For a change, let *us* do it, and let *George* watch.

(signed) *Victor G. Raviolo*

*Reprinted herewith

N.J. Section Helps Formulate Instrumentation Courses

The Educational activities of the New Jersey Section, ISA, have expanded into the field of the Engineering College. The Section, in cooperation with the Newark College of Engineering, has formulated four special courses in the Field of Industrial Instrumentation which are now in progress at the college. These tuition courses, given in the evening and lasting from 15 to 18 weeks are designed to attract instrument men from various levels of education and experience. The course titles are: "Elements of Industrial Instrumentation," "Industrial Instrumentation Applications," "Fundamentals of Industrial Automatic Control," and a seminar, "Automatic Control Theory and Analysis."

A committee of college faculty and ISA members determine admission to the seminar. ISA members are given preference to the limited enrollment course, "Fundamentals of Industrial Automatic Control."

Course descriptions and prerequisites to admission are as follows:

ELEMENTS OF INDUSTRIAL INSTRUMENTATION

This is a basic course at an elementary level covering the measurement of temperature, pressure, flow, and level. The course will include some elementary principles of physics, upon which the measurements are based, and the basic types of equipment used in industry. Approximately sixty percent of the time will be devoted to lecture-discussion and forty percent to demonstration.

Course Content: Introduction—an elementary discussion of energy, temperature scales, pressure-volume-temperature relationships and the physical properties of gases, liquids and solids. Temperature Measurement—the measurement of temperature by means of mercury in glass and vapor tension thermometers, bimetallic strips, thermoelectric and resistance thermometry will be included. Pressure Measurements—absolute and differential pressure measurements; basic types of low, medium and high pressure instruments. Flow Measurements—differential and volumetric types of flow meters. Liquid Level Measurement—direct and indirect including visual, float, electrical contact, pressure and photoelectric applications.

Prerequisites: High school diploma or by permission of the department.

Schedule: 2½ hours per evening, Wednesday evening each week for 18 weeks—45 hours commencing Oct. 12, 1949.

INDUSTRIAL INSTRUMENTATION APPLICATIONS

Course Content: Each of the four classifications—Flow, Temperature, Pressure, Level—will be presented by an instructor with an industrial background. For each classification the material presented will cover: available types of measuring elements and methods, their limitations, and factors which determine selection for specific cases in various fields of application. The instruction will include the illustration of many problems by working out specific examples. Actual cases suggested by the students can be included. In addition, problems specific to each class will be covered, a few examples of which are listed below.

FLOW: Flow computations for orifice, nozzle, Venturi and pitot tube; main line and connection piping application considerations; accessories such as seals, condensers, purge systems.

TEMPERATURE: Installation design of primary element, including wells, immersion; ambient temperature effects.

PRESSURE: Pulsating pressures; compensation for static heads and for atmospheric pressure.

LEVEL: Atmospheric and pressure installations; dual gravity services.

Prerequisites: High school diploma, successful completion of first-year college mathematics, plus two years practical experience in the fundamentals of industrial measurements.

Schedule: 2 hours per evening, Monday and Wednesday evenings each week for 15 weeks—60 hours, commencing Oct. 10, 1949.

FUNDAMENTALS OF INDUSTRIAL AUTOMATIC CONTROL

Course Content: This course is designed for technicians, foremen, supervisors and Instrument Engineers. The course will include control theory, types and mechanisms of automatic control, applications of automatic control in industrial processes as well as the following topics: Measuring Means of Industrial Control, Characteristics of Measuring Means, Modes of Automatic Control, Final Control Elements, Process Characteristics, Theory of Automatic Control, Quality of Automatic Control and Application Control Engineering.

Prerequisites: High School diploma, successful completion of first-year college mathematics, plus two years practical experience in the fundamentals of industrial measurements.

Schedule: 2 hours Friday evening each week for 16 weeks—32 hours, commencing Oct. 14, 1949.

SEMINAR ON AUTOMATIC CONTROL THEORY AND ANALYSIS

Course Content: This is an advanced course on automatic control theory and analysis which will be run on a seminar basis. The first three sessions will be devoted to a mathematics review up to differential equations. Such professional society papers as those of Zeigler-Nichols on optimum, controller adjustments and process reaction curves will form the subject matter for round table discussions. The advanced portions of Eckman's text will also be studied. Each student will have the opportunity of guiding one of the sessions.

Prerequisites: Engineering or Science graduate with responsible charge in the field of instrumentation.

Schedule: 2 hours per evening, Monday evening each week for 18 weeks—36 hours, commencing Oct. 10, 1949.

Out Of A Job ?

Let's assume you are out of a job. What will you do?

YOU are thinking that this assumption is pretty ridiculous—but wait! Is it so foolish?

Let's set up a hypothetical case, using you as an example:

Production has fallen off in your plant and, because you haven't enough seniority, or other reasons with which only you are familiar, you are laid-off. (You say it can't happen? Don't kid yourself!)

So, now you are out of a job. But you're not worried, you'll get another in a hurry. You might as well take it easy for a couple of days—you haven't had a real vacation for a long time and, starting on a new job, you won't get any time off for a while.

You relax, take it easy, knock about and go fishing or hunting, and spend money like you really had it.

About a week of that and you start thinking about looking for work.

You make a few 'phone calls to guys you know in the business and their answers are: "things are kinda slow here now, call later."

Now you begin to wonder a little bit.

You called on four places today. The answer; "We're not hiring now." . . . Oh, well, tomorrow you'll connect!

Tomorrow comes and out you go again. Now it develops that before you can be put on, men who were laid off have to be recalled first. . . . *Hey! What is this?*

A couple of weeks have gone by—no job—no prospects for a job—your feet are tired—your money is getting low. You're disgusted and discouraged. If it gets much worse you'll have to move in with your in-laws. *Oh no, not that!*

Finally, a bright light flashes in your head. The Instrument Society! Why didn't you think of good old ISA before? They conduct an employment service for members only. You've been a member and you've never asked for anything. You'll give it a try. Anyway, its your last chance—they are the only ones to turn to now.

You contact the Chairman of your ISA Local Section Employment Committee. He tells you things have been so quiet with his committee for years, that his files are completely inactive. He's had no request for help from members, and no employers contacting him for qualified technicians.

You are really over a barrel now. No one to turn to. . . . Nothing but unemployment compensation!

* * *

After having read this far, you are probably saying, "So what?"

Well, here is our problem:

The story we have just told you can happen, you know. And, before any such situation should develop, we want to be fully prepared to help you in a manner that, with a minimum effort on our part, permits us to be of maximum assistance to you.

Up to now the Employment Committees haven't had to be very active, owing, in the past, to a shortage of trained and experienced instrument technicians, engineers and sales representatives. The Help Wanted files are pretty thin, if not nonexistent. And the Jobs Available files are now being depleted by men who have needed help.

In recent months it has become apparent that more and more men are in need of help. This is evidenced by the increased number of applications received for jobs listed in the Journal of ISA in *Instruments*.

Because the employment situation throughout the country is now noticeably more critical, some constructive planning must be done in order to alleviate a condition which we all hope will never come to pass.

Our first step is one designed to place in the hands of the ISA National Office a list of all companies employing instrument men (technicians, engineers and sales representatives) and the name of the person responsible for hiring such personnel.

* * *

Here is where YOU come in! This is a job we can't do alone.

Will each of you who reads this, communicate (by letter or telephone) with your local section Employment Committee Chairman, or the National Employment Committee Chairman in Pittsburgh, and relay to him (1) the names of companies using and employing men with instrument knowledge and (2) the names of the persons who do the hiring?

Here is how we can use this information when we get requests for employment help:

The employer will be contacted by the Employment Committee Chairman, either by letter or by telephone, giving the background and experience of the member desiring help.

If the employer is interested the member is notified by the Employment Committee Chairman. The ISA then steps out of the picture, leaving the employer and the member to come to terms.

If this first contact isn't mutually satisfactory, the Employment Committee then continues its search to place the member, and refers someone else to the first employer for consideration.

In this manner the employer's name is not publicized and he is not deluged with interviews.

All Chairmen of Employment Committees must be discreet in the handling of employer contacts.

At no time should the list of employers be published or be open for casual inspection.

Members desiring job placement help from ISA will contact their local Employment Committee Chairman. The Chairman alone should shoulder the burden of responsibility involved in contacting the prospective employer and placing before him the qualifications of the member being helped.

Make no mistake—ANY INDISCRIMINATE USE OF THIS LIST WILL DESTROY THE VERY THING WE ARE ATTEMPTING TO DO—to help ISA members when and if they need job placement assistance.

A value of this list which we can't overlook, is the fact that we will have a rather complete over-all picture of the nation-wide employment situation.

Too, having a national-scope listing of companies employing men with a knowledge of instrumentation will permit a far greater field of operation in helping a man, should the local areas have nothing to offer.

A closer integration and cooperation between Section Employment Committee Chairmen is now, more than ever, necessary to a complete fulfillment of our proposed program.

Remember, each of you who reads this may one day be in need of a job—and who better to turn to than your Society?

It would be well to point out at this time that employers, too, can profit by submitting their names for listing. In this way, the employer can be made aware of the availability of a well qualified man.

If the employer lists the particular qualifications necessary for employment with his firm, he can be sure that no reference will be made to him of persons of other categories.

So, will each and every one of you who reads this, please spread the word and place your faith and trust in the ISA Employment Committee. We promise that, with your help, we will do our very best to offer the kind of assistance you expect from us.

Get behind ISA—send in the names of employing companies and employing supervisors. The ISA will get behind you.

Remember the addresses: Your local section Employment Committee Chairman; or Chairman, National Employment Committee, 921 Ridge Ave., Pittsburgh 12, Pa.

ROY JOHNSON, Chairman
Employment Committee,
Chicago Section.

Section Secretaries, Meeting Data and Programs

ALBUQUERQUE
E. R. Deeter, Eng. Dept., University of California, Los Alamos Scientific Laboratory, P.O. Box 5800, Albuquerque, N. M.

AKRON
Fred Appel, 932 Columbia Ct., Barberton, Ohio.
Fourth Tuesday, Meeting at 8:00 P. M.

ARUBA
A. S. MacNutt, c/o Lago Oil & Transport Co., Ltd., Aruba, N.W.I.
First Tuesday, Meeting at 7:15 P. M.

ATLANTA
H. Kockritz, Fischer & Porter Co., 84 Peachtree St., Atlanta, Ga.
Fourth Monday, Meeting at 7:45 P. M.

BALTIMORE
P. Donahue, Maryland Glass Corp., Mt. Winans, Baltimore, Md.
Second Friday.

BATON ROUGE
James H. Simpson, 3647 Gladiola, Baton Rouge, La.

BOSTON
C. J. Nazzaro, 456 Central Avenue, Milton 87, Mass.
Last Wednesday, Dinner at 6:00 P.M., Meeting at 7:00 P.M.

CALIFORNIA
D. D. Taylor, 234 E. Colorado, Pasadena 1, Calif.
First Tuesday, Dinner at 6:30 P.M.

CENTRAL ILLINOIS
H. F. Lange, 2101 W. Glen Avenue, Peoria 5, Ill.
First Wednesday, Dinner at 6:30 P.M., Meeting at 7:30 P.M.

CENTRAL INDIANA
H. F. Coffey, 110 G Nelson Ave., Tyndall Towne, Indianapolis, Ind.
First Tuesday, Meeting at 7:30 P. M.

CHARLESTON
Albert H. Hix, 1529 B Dixie St., Charleston 1, W. Va.
First Monday, Dinner at 6:30 P.M., Meeting at 8:00 P.M.
December 5, Kanawha Hotel, Charleston. "Gadgets," R. D. Webb, Carbide & Carbon Chemical Corp.
January 9, "The Maintenance of pH Instruments," E. A. Bryant, E. I. Dupont de Nemours.

CHICAGO
Floyd E. Ertsman, Rm. 1420 Fisher Bldg., 343 S. Dearborn St., Chicago, Ill.
First Monday, Dinner at 6:30 P.M., Meeting at 8:00 P. M.
December 6 (Tuesday). Peoples Gas Co. Auditorium, "Inverse Derivative," C. B. Moore, Moore Products Co. No Dinner.
December 20 (Tuesday). Western Society of Engineers (84 E. Randolph St.,). "Flow Plan Symbols," Dave Hostedler, Foster Wheeler Co.

CHINA LAKE
A. G. DeBell, U. S. Naval Ordnance, Test Sta., China Lake, Calif.

CINCINNATI
Edward H. Muhleisen, 320 Durrell Ave., Cincinnati 15, Ohio
Third Friday, Meeting at 8:00 P.M.

CLEVELAND
R. M. Woodside, Brown Instrument Div., Minneapolis-Honeywell Reg. Co., 5005 Euclid Ave., Cleveland 5, Ohio
Fourth Wednesday, Dinner at 6:30 P.M., Meeting at 8:00 P.M.

COLUMBUS
Orval Linebrink, c/o Battelle Memorial Institute, 505 King Ave., Columbus, Ohio

CUMBERLAND
Clyde Babat, P.O. Box 447, Cumberland, Md.
Tuesday after Fourth Monday, Dinner at 6:30 P.M., Meeting at 8:00 P.M.

DETROIT
Seymour Sterling, 13331 Linwood, Detroit, Mich.
Third Tuesday.

EASTERN NEW YORK
J. M. Wilsey, c/o General Engineering & Consulting Lab., General Electric Company, Schenectady, N. Y.
First Tuesday, Dinner at 6:30 P.M., Meeting at 8:00 P.M.

GULF COAST
A. E. Bunn, 2237 North St., Beaumont, Texas
Third Tuesday.

HOUSTON
E. E. Kleir, 2518 S. Blvd., Houston 6, Texas
Last Monday, Meeting at 8:00 P. M.

KANSAS CITY
Lewell F. Spies, c/o J. F. Pritchard & Co., 908 Grand Ave., Kansas City, Mo.
Last Tuesday, Dinner at 6:30 P. M., Meeting at 7:30 P. M.

LOUISVILLE
H. C. Schermus, 980 Palarka Rd., Louisville, Ky.
Fourth Tuesday, Meeting at 8:00 P.M.

MONTREAL
L. J. Mizuhara, Monsanto (Canada) Ltd., 425 St. Patrick St., Ville LaSalle, Quebec, Canada
Last Monday, Meeting at 8:00 P.M.

NEW JERSEY
W. D. Archibald, 605 Westminster Ave., Elizabeth 3, N. J.
First Tuesday, Dinner at 6:00 P.M.

NEW ORLEANS
W. H. Hancy, 2927 Music Avenue, New Orleans, La.
No Regular Date, Meeting at 8:00 P.M.

NEW YORK
Norman J. Cherry, Merrick, L. I., N. Y.
Last Monday, Dinner at 6:30 P.M., Meeting at 8:00 P.M.
Special Program Series—Pressure Measurement; November 14—Flow Measurement; December 12—Density Measurement; January 16—B.T.U. Measurement.

NIAGARA FRONTIER
Mrs. James L. Martin, 697 Potomac Ave., Buffalo 9, N. Y.
Fourth Monday, Dinner at 6:15 P.M., Meeting at 8:00 P.M.

NORTH TEXAS
R. E. Byers, 6000 Lemmon Ave., Dallas 9, Texas

NORTHERN CALIFORNIA
M. A. Dimmick, 5607 Alta Punta, El Cerrito, Calif.

NORTHERN INDIANA
J. Baum Beckman, 547 N. Waller Ave., Chicago 44, Ill.
Third Wednesday, Dinner at 6:30 P.M., Meeting at 7:30 P. M.

OAK RIDGE
John H. Clark, 138 Clayton Hall, Oakridge, Tenn.
First Wednesday, Dinner at 6:30 P.M., Meeting at 7.30 P. M.

ONTARIO
John W. Huether, 311 Southerland Dr., Leaside, Ontario, Canada
Third Thursday, Dinner at 6:45 P.M.

PHILADELPHIA
C. W. Wood, 6908 Market St., Upper Darby, Pa.
Third Wednesday, Meeting at 8:00 P.M.

PITTSBURGH
Miss Louise Suckfield, P.O. Box 2038, Pittsburgh 30, Pa.
Fourth Monday, Dinner at 6:30 P.M., Meeting at 8:00 P.M.
December 19, "Magnetic Amplifiers," F. N. McClure, Westinghouse Electric Corp.
January 23, "Stump the Experts." A Maintenance Clinic moderated by Charles B. Cochran, Peter Loftus Corp.

PRESQUE ISLE
Edwin P. Schuwerk, 445½ Halley St., L. P., Erie, Pa.
Fourth Tuesday, Meeting at 8:00 P.M.
November 22, "Fundamentals of Measurements," E. J. Hatfield Jr., General Electric Co.
January 24, Open forum on instrumentation problems.
February 27, "Control Valves," T. L. Smith, Belfield Valve Div., Minneapolis-Honeywell Regulator Co.

RICHLAND
R. S. Hammond, 402 Abbott, Richland, Washington
Second Wednesday, Meeting at 7:30 P.M.

ROCHESTER
R. C. Swartz, Jr., 1201 Granite Bldg., Rochester 4, N. Y.
Fourth Tuesday, Meeting at 8:00 P.M.

ST. LOUIS
W. G. Lee, 4710 Delor St., St. Louis 16, Mo.
First Wednesday, Meeting at 8:00 P.M.
December 7, "Precision Temperatures Measurement & Control," Geo. C. Graf, Leeds & Northrup.

SARNIA
Fred T. Yarke, 140 St. Clair St., Point Edward, Ontario, Canada
Second Friday.

SOUTH BEND
Sam M. Rouse, 436 Moccasin Ave., Buchanan, Mich.
First Thursday, Dinner at 6:30 P.M., Meeting at 7:30 P.M.

SOUTH MICHIGAN
Homer Kuiper, 2517 Hillsdale, Kalamazoo, Mich.
Second Wednesday, Dinner at 6:30 P.M., Meeting at 8:00 P.M.

SOUTH TEXAS
H. C. Givens, La Gloria Corp., P.O. 637, Farfurrias, Texas
First Tuesday, Meeting at 7:30 P.M.

TENNESSEE
N. M. Taylor, 16 Edgewood, Kingsport, Tenn.
No definite night, Dinner at 7:00 P.M., Meeting at 8:00 P.M.

TULSA
C. R. Horton, 8211 E. 7th, Tulsa, Oklahoma
First Monday, Meeting at 7:30 P.M.

TWIN CITIES
Alden Hine, c/o Giesika & Pinkney, 552 Plymouth Ave., 6th & Hennepin Ave., Minneapolis 8, Minn.
Fourth Tuesday, Dinner at 6:30 P.M.

WASHINGTON
Edwin G. Brown, c/o American Instrument Co., 8010-20 Georgia Ave., Silver Springs, Md.
Third Monday, Meeting at 7:30 P.M.

WAYNE COUNTY
Robert Karr, 2455 Biddle Ave., Wyandotte, Michigan
Third Monday, Dinner at 6:30 P.M., Meeting at 8:00 P.M.

ISA EMPLOYMENT SERVICE

Forward your letter to INSTRUMENT SOCIETY OF AMERICA, 921 Ridge Ave., Pittsburgh 12, Pa.

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INSTRUMENTATION ENGINEER. Pulp and paper field, well established firm, a leader in its field needs services of graduate engineer experienced in pulp and paper instrumentation. Position will involve product development and sales engineering. Compensation plan is attractive and gives full recognition of individual effort. Location: Minnesota. Box 253.

• • •

MANUFACTURERS REPRESENTATIVE. For engraved stem thermometers and mercury in glass thermostats. Must be experienced and familiar with the trade for the territory of New York, New Jersey, Maryland and Virginia. Box 254.

• • •

INSTRUMENT MECHANIC. Qualified to maintain, repair and devise instruments for large chemical organization. Location: Tennessee. Box 255.

• • •

SALES ENGINEER. Experienced with regulating valves and instrumentation. Old established company now expanding its sales force has an opening for man capable of developing into district sales manager. Location: Southern Ohio. Box 256.

• • •

SALES ENGINEER. Not over 40 years of age with some engineering training and experience in industrial instrumentation applications, knowledge of automatic control valves desirable. After training period will sell to contractors, engineers and industrial plants. Commission with initial drawing account. Employer estimates new man could earn between $3000 and $4000 per year and continue upward as he becomes better qualified. Location: Washington, D. C. Box 257.

JOURNAL of the Southern California Meter Association

President: Robert F. Fields — Auditor: John T. H. Morris
Vice-President: James E. Adams — Past-President: J. C. Groenewegen
Secretary-Treasurer: George H. Foster, 2916 Eucalyptus Ave., Long Beach 6, Calif.

Continuous Electronic Water-content Measurements *in* Oil-field Emulsions*

By P. O. ENGELDER, Oil Well Water Locating Co., Long Beach, Calif.

IT is indeed unfortunate that the genesis of a petroleum accumulation and its subsequent production are so inextricably allied with the occurrence and movement of subterranean waters, for, although water is practicably insoluble in oil, it is well known that crude oil, as it is produced from wells, often carries a high water content. This water is, of course, emulsified, and is a source of great technical difficulty. The magnitude of the problem is apparent when it is realized that at least 30 percent of the crude produced in the United States contains emulsified water in appreciable quantities. The marketability of the oil is lessened; production costs are increased; and corrosion problems intensified by the occurrence of this water.

It is axiomatic that to control a condition one must first measure it; and it is intended to describe equipment designed to provide a continuous record of the water content of oil flowing, for example, in a shipping line. Present-day technique consists of the withdrawal of small samples (the frequency of physical sampling determined by the situation) and obtaining the water content of the sample by centrifuging or distillation. Not only is this practice subject to human error—as one engineer puts it, "the accuracy of sampling is inversely proportional to the state of fatigue of the gauger"—but it further suffers in validity as a result of the inconsistency of well production. The record of water content vs. time illustrated in Fig. 1 is more often the rule than the exception; the validity of any single sample throughout the 24-hour period depicted on this chart is questionable, to say the least!

Obviously, some sort of CONTINUOUS record of the variation in water content, or "cut," as it is termed, is needed; this type of record is provided by the equipment shown in Fig. 2. The physical basis of the measurement resides in the determination of an electrical characteristic of the emulsion known as the dielectric constant, which, owing to the abnormally high dielectric constant of water, is a very sensitive indicator of water content.

*Presented before the Southern California Meter Association, Los Angeles, Calif., September 15, 1949.

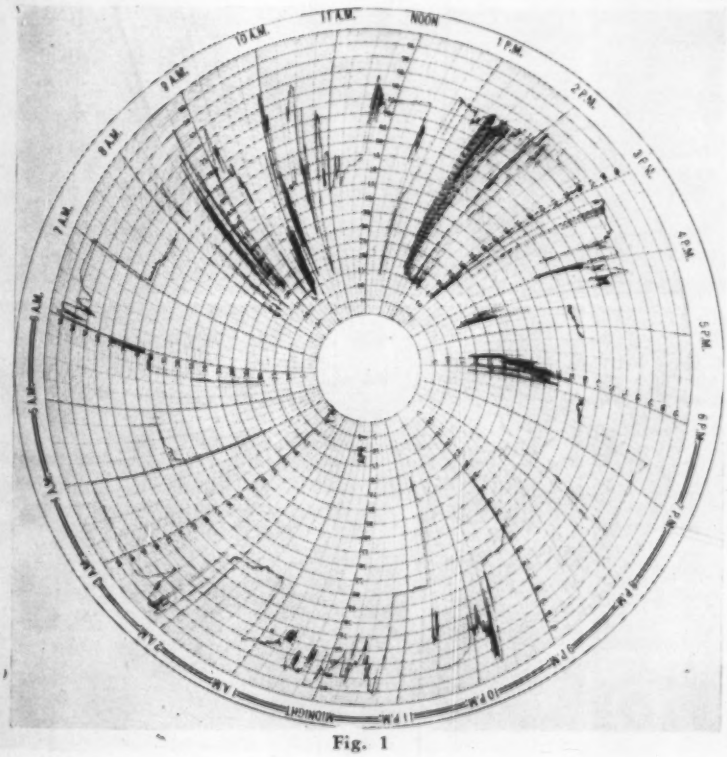


Fig. 1

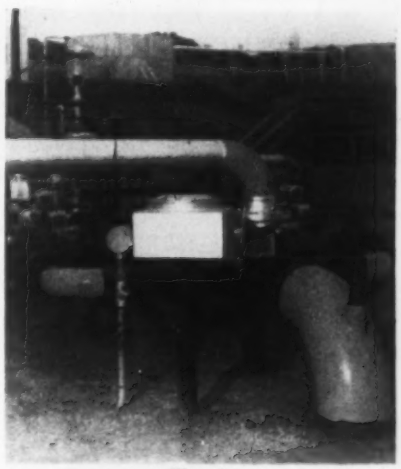


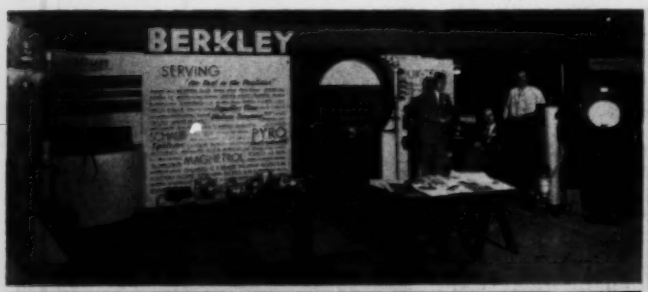
Fig. 2

An emulsion is a system consisting of two liquid phases, one of which is dispersed as globules within the other. The two liquids must be immiscible, or nearly so; e.g., the true solubility of water in oil is of the order of 0.05 percent and the true solubility of oil in water is practically nil. The liquid broken up into globules is known as the dispersed, or internal, phase; while the component surrounding the globules is called the continuous, or external, phase. Two families of emulsions are theoretically possible, depending upon whether the water is dispersed in the oil, or vice-versa. The vast majority of oil-field emulsions are of the water-in-oil type; the dispersion of the globules varies throughout a wide range. In some extremely "tight" emulsions the water globules are from one to five microns in diameter; coarse emulsions have been encountered in which the globule diameter ranged from 25 to 200 microns. (*Continued on page* 1066)

View of part of one of the three aisles.

TWENTY-SECOND ANNUAL EXPOSITION *OF THE* SOUTHERN CALIFORNIA METER ASSOCIATION

Long Beach Municipal Auditorium, Oct. 4-5-6, 1949



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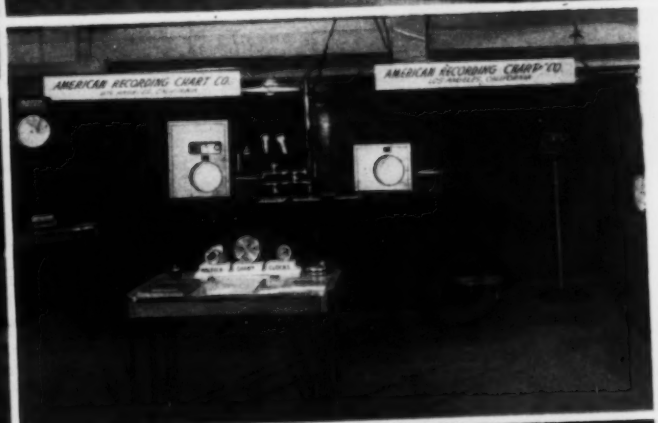
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(*Continued from page* 1063)

In all emulsions with the exception of the very dilute oil-in-water type, the oil hydrosols, the presence of a third substance, the emulsifying agent, is necessary to add stability to the system. Asphaltic material, argillaceous material in colloidal suspension with the oil, or both, serve as emulsifying agents in most oil-field emulsions. Agitation, or other physical disturbance resulting in dispersal of one phase within the other, in the presence of the emulsifying agent, promotes emulsion formation. It has been quite definitely established that oil-field emulsions are formed in the production equipment of the well, although the possibility of emulsification occurring at emergence of production fluids from the sand into the well bore exists in some cases.

Returning now to the electrical measurement of the water content of the two-phase system, one may define the dielectric constant as "a measure of the work required to orient the molecules, under the influence of an external electric field, against their random thermal agiation.* To aid in more complete understanding of the source of the anomalously high value for the dielectric constant of water (a value of 80 compared to 2.2 for petroleum) it is helpful to introduce the concept of the polar molecule. A polar molecule lacks electrical symmetry; its centers of positive and negative charge are separated by a finite distance, and consequently it is difficult to orient and may oscillate rotationally when placed in an alternating field, thus dissipating energy. On the other hand, a non-polar molecule, one possessing physical and electrical symmetry, is capable of being oriented by an external field with much greater ease and, theoretically, exhibits no power loss in an alternating field. The net result is a tremendous contrast in dielectric constant between the highly polar water molecule and the non-polar petroleum, thus imparting great sensitivity to water determination methods based on the measurement of dielectric constant.

The Enniscope equipment makes such a measurement by passing the liquid to be measured through a capacitor comprising two concentric cylinders. This capacitor can be inserted at any convenient point in the pipeline and is energized by a source of high-frequency energy. The electronic equipment generating this high-frequency energy and the associated measuring circuits are housed in a rugged weatherproof condulet, connected to the recorder through electrical conduit; shielded weatherproof coaxial cable carries the signal from the electrode to the electronic equipment. The capacitance and the power loss exhibited by the test capacitor are a function of the water content of the emulsion and, through suitable control circuits, the recorder pen is caused to deflect proportionally to the water content, thus providing, in effect, a continuous sampling of the fluid flowing through the pipeline.

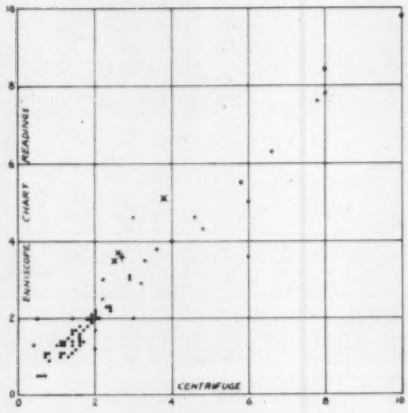

Fig. 3

The effective dielectric constant of a water-in-oil emulsion is not a linear function of the water content, but, through proper choice of electrode geometry and circuit constants, the recorder pen deflection may be made linear within about plus or minus 3 percent of full range. A typical accuracy plot, obtained by plotting chart reading vs. centrifuged water content for a large number of samples, is shown in Fig. 3. This plot is interesting in several respects. Some points deviate grossly from the faired curve, which is substantially linear; these points, in the author's opinion, represent contaminated samples. The trend is too obvious and the statistical evidence too powerful to permit one to attribute the gross discrepancies to the electronic equipment. Smaller discrepancies between chart reading and physical water content by centrifuge may be attributed to two factors. First, ASTM standards permit a margin of 0.4 percent between two results from any one sample; laboratory techniques, admittedly, generally provide results in much closer agreement, but one is forced to conclude that the water content is never known to closer than 0.2 percent. Second, the accuracy of the present Enniscope equipment in the 0-10 percent range is limited to approximately 0.2 percent, owing primarily to such factors as globule size and distribution.

The four starred samples in the 2-4 percent region exhibiting a uniform positive error illustrate an interesting point. These samples represent readings made on a crude that was heavily "cut," or diluted, with a gas-oil containing a high percentage of aromatic hydrocarbons. This was done to reduce the viscosity of the crude for ease of pumping. The contamination of the crude by the gas-oil containing a high percentage of polar molecules resulted in erroneous chart readings, for the equipment responded to the presence of these aromatic hydrocarbons as well as to water, although to a lesser degree, of course. Compared to a sample of crude oil, the gas-oil in question possessed a dielectric constant equivalent to a 3 percent water content, although it actually contained only a trace of water. Consequently, it is important that the equipment be calibrated with the type of crude with which it is intended to be used, and that any possibility of contamination of the fluids by polar liquids be considered.

This equipment has been proved in actual practice over a period of two years. Three full-scale sensitivities, 0-5, 0-10, and 0-100 percent, are presently available. Maintenance consists largely of tube replacement at six-month intervals. Properly calibrated, the equipment provides a continuous record of "cut" that is comparable in accuracy to that provided by the most careful physical sampling techniques, with the advantages that human errors in sampling and laboratory technique are virtually eliminated and a complete chronological record of water content variation is available rather than the results of spot samples taken at intervals.

*Williams and Cuelby, *Journal of Rheology*, Vol. 2, 1931, page 271.

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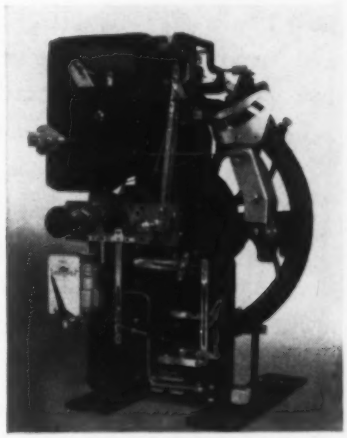

Front view (chart removed) of Hagan Pressure-Compensated Ring Balance Meter. This particular model is equipped with three pens, indicating uncorrected flow on a strip indicator (not shown), and recording pressure and corrected flow. Corrected flow is continuously totalized by the integrator (upper left).

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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on Page 1071.

R-584 COMBUSTION SAFEGUARD. 8-page Bulletin W1816 illustrates and describes maker's "Pyrotrol" combustion safeguard; contains specifications, diagrammatic charts; lists features.—The Bristol Co., Waterbury 91, Conn.

R-585 "THE OHMITE NEWS." 2-page July-August issue of this house organ features article titled "Syntron Electric Vibrators Use Ohmite Rheostats for Smooth Control."—Ohmite Mfg. Co., 4835-41 Flournoy St., Chicago 44, Ill.

R-586 CO_2 ANALYZER. 4-page Bulletin 710 describes and illustrates maker's CO_2 analyzers; stresses importance of efficient combustion; contains charts, diagram.—Charles Engelhard, Inc., 850 Passaic Ave., East Newark, N. J.

R-587 AIR DRYERS. 4-page Bulletin 16.0.080 illustrates and describes maker's line of "Hydryers" for drying gases, air or liquids; discusses designs, specifications.—J. F. Pritchard & Co., 908 Grand Ave., Kansas City 6, Mo.

R-588 PYROMETER CONTROLLER. 12-page bulletin describes and illustrates maker's electronic pyrometer controller; discusses uses, operation; contains diagrams, specifications.—Loudon Instruments, Inc., Chicago 11, Ill.

R-589 FLOW MEASUREMENT. 24-page Catalog No. 50 illustrates and describes maker's line of "Ratomatic" instruments for remote indicating, controlling, totalizing; contains drawings, specifications.—Fischer & Porter Co., Hatboro, Pa.

R-590 ELECTRICAL CONTROL SYSTEMS. 34-page bulletin describes and illustrates maker's control systems; discusses several installations; describes convertible instrument truck, control panels.—W. F. and John Barnes Co., 301 S. Water St., Rockford, Ill.

R-591 TUBE FITTINGS. 60-page Catalog No. 203 lists and illustrates maker's line of tube fittings; contains design data, specifications.—The Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

R-592 PRECISION RESISTORS. 4-page bulletin describes and illustrates maker's "Multipot" helical type, precision voltage dividers; contains drawings, specifications.—Ford Engineering Co., Box 153, Los Angeles 41, Calif.

R-593 VIDEO TEST INSTRUMENTS. 8-page bulletin illustrates and describes maker's cathode-ray oscilloscopes and video test instruments; contains features, characteristics, specifications.—Tektronix, Inc., 712 S.E. Hawthorne Blvd., Portland 14, Ore.

R-594 RADIO-TV TEST EQUIPMENT. 2-page bulletin describes and illustrates maker's oscillograph, sweep generator, etc.; lists specifications, special features.—Jackson Electrical Instrument Co., Dayton 1, Ohio.

R-595 SUBMINIATURE ACCELEROMETER. 2-page Bulletin No. 4.4 describes and illustrates maker's "Model F" subminiature accelerometer; lists special features, specifications, selection table.—Statham Laboratories, 9328 Santa Monica Blvd., Beverly Hills, Calif.

R-596 RECTANGULAR COORDINATE RECORDER. 8-page bulletin describes and illustrates maker's "Type 373" rectangular coordinate recording system; contains general description, specifications.—Airborne Instruments Laboratory, 160 Old Country Rd., Mineola, N. Y.

R-597 WIDE-RANGE OSCILLATOR. 2-page bulletin illustrates and describes maker's "Type 124 A" wide-range power oscillator; lists applications, specifications. — Airborne Instruments Laboratory, 160 Old Country Rd., Mineola, N. Y.

R-598 "BIDDLE INSTRUMENT NEWS." 4-page Vol. 5, No. 3 issue of this house organ features a section titled "Question and Answers on Insulation Testing," and other articles.—James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa.

R-599 PAPER TESTING. 4-page Bulletin No. 4907 describes and illustrates maker's basis weight scales; lists specifications, uses.—Thwing-Albert Instrument Co., Pulaski Ave. at Penn St., Philadelphia 44, Pa.

R-600 "THE BODINE MOTORGRAM." 4-page Vol. 29, No. 5 issue of this house organ features article titled "Electric Brain Speeds Up Difficult Calculations."—Bodine Electric Co., 2250 W. Ohio St., Chicago 12, Ill.

R-601 PICTORIAL BROCHURE. 44-page brochure illustrates and describes maker's facilities for instrument manufacture; lists line produced.—Cook Research Laboratories, 1457 Diversey Parkway, Chicago 14, Ill.

R-602 MERCURY SWITCHES. 16-page Catalog 1343 describes and illustrates maker's line of mercury switches; gives engineering data, specifications; discusses advantages, applications.—Brown Instruments Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

R-603 SCIENTIFIC GLASSWARE. 24-page Bulletin 8149 describes and illustrates maker's laboratory stopcocks and interchangeable joints; lists specifications, structural details, uses.—Boder Scientific Co., 719-721 Liberty Ave., Pittsburgh 22, Pa.

R-604 WATCH CLEANING MACHINE. 4-page bulletin illustrates and describes maker's "Little Giant" watch cleaning machine; lists special features, design.—H & H Horological Supply Co., 1549 Lawrence St., Denver 2, Colo.

R-605 "THE OSCILLOGRAPHER." 20-page Vol. 11, No. 3 issue of this house organ features articles on maker's "Type 314-A Oscillograph-Record Camera," an article titled "A New Lens for Projection Oscillography," and others.—Instrument Div., Allen B. Du Mont Laboratories, Inc., 1000 Main Ave., Clifton, N. J.

R-606 "THE GENERAL RADIO EXPERIMENTER." 8-page, Vol. XXIV, No. 2 issue of this house organ features an article titled "A New Decade Inductor."—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

R-607 "TEMPERATURE-RESISTANCE CHARACTERISTICS OF ELECTRICAL INSULATION." 16-page Technical Publication 21T4 discusses problems and factors in determining temperature-resistance characteristics of electrical insulation.—James G. Biddle, Co., 1316 Arch St., Philadelphia 7, Pa.

R-608 DISTANT READING THERMOMETERS. 8-page Bulletin No. 2451-C describes and illustrates maker's distant reading electric ther-

nometers; lists ranges available, applications, specifications. — Illinois Testing Laboratories, Inc., 420 N. La Salle St., Chicago 10, Ill.

R-609 GRATING SPECTROGRAPHS. 12-page Bulletin XXXII describes and illustrates maker's line of spectrographs; lists advantages, specifications.—Baird Associates, Inc., 33 University Rd., Cambridge 38, Mass.

R-610 MULTI-CIRCUIT PYROMETER. 2-page bulletin illustrates and describes maker's "Type 1200" portable multi-circuit pyrometer; discusses features, construction, specifications.—Illinois Testing Laboratories, Inc., 420 N. La Salle St., Chicago 10, Ill.

R-611 SHUT-OFF COCKS. 24-page Bulletin 100-1 describes and illustrates maker's line of extra-grade cocks: acid metal, gland-packed, roundway, pet and bibb cocks, etc.; also stop, check, non-return and transfer valves.—Belfield Valve Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

R-612 "THE GENERAL RADIO EXPERIMENTER." 8-page Vol. XXIV, No. 3 issue of this house organ features article titled "Measuring Noise Levels on Frequency-modulated Transmitters."—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

R-613 VACUUM THERMOCOUPLES. 4-page Bulletin V23 describes and pictures maker's "Type U" UHF vacuum thermocouples; gives dimensions, overload, type of response.—Field Electrical Instrument Co., 109 East 184th St., New York 53, N. Y.

R-614—TRANSMISSION AND ABSORPTION DYNAMOMETER. 2-page bulletin illustrates and describes maker's "Model E" transmission and absorption type dynamometer; discusses features and operation.—Electro Mechanical Devices Co., 49 Selden Ave., Detroit 1, Mich.

R-615 MOTOR TESTING DYNAMOMETER. 4-page bulletin illustrates and describes maker's "Model 48" absorption type electric motor testing dynamometer; lists speed and hp. range, capacity; discusses assembly, control.—Electro Mechanical Devices Co., 49 Selden Ave., Detroit 1, Mich.

R-616 RADIOACTIVITY MEASUREMENT. 8-page bulletin describes and illustrates maker's "Raychronometer" for precise measurement of radioactivity with Geiger tubes; lists features, specifications, discusses component elements.—Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.

R-617 LIQUID LEVEL GAGE. 2-page Bulletin 120 describes and illustrates maker's "Truscale" distant-reading dial-type gage for boiler and other water levels; discusses construction, special features, operation.—Jerguson Gage & Valve Co., 80 Fellsway, Somerville 45, Mass.

R-618 FORCE MEASUREMENT. 2-page bulletin illustrates and describes maker's "Unibeam" uni-directional force-measurement device for new dynamometer installations or replacement of old torque-measuring equipment; lists features.—Link Engineering Co., 13845 Elmira Ave., Detroit 27, Mich.

R-619—TUBE FITTINGS. 2-page Bulletin 219 contains shape nomenclature chart and tube fitting size table on maker's industrial 3-piece tube fittings.—The Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

R-620 CONTROL PANELS. 2-page bulletin illustrates and describes maker's machine-tool control panels; lists features, discusses maintenance, construction.—Electro Mechanical Devices Co., 49 Selden Ave., Detroit 1, Mich.

R-621 "HOW TO SERVICE RADIOS WITH AN OSCILLOSCOPE." 72-page booklet, price $1, explains in a practical manner the operation and applications of the cathode-ray oscilloscope; essentially for radio and amplifier repairmen, etc.—Radio Div., Sylvania Electric Products Inc., 500 Fifth Ave., New York 18, N. Y.

R-622 CAPACITOR BANK. 2-page bulletin illustrates and describes maker's capacitor bank;

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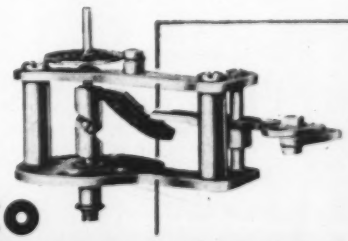

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Maximum undistorted deflection	2.5 cm. each way from center.
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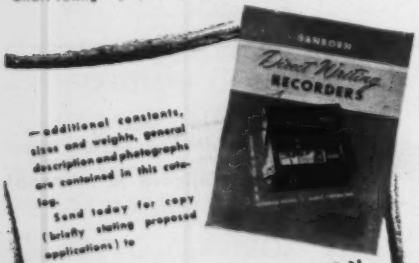

— additional constants, sizes and weights, general description and photographs are contained in this catalog.

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R-623 INSTRUMENT MOTORS. 4-page bulletin pictures and describes maker's "Type R-25" synchronous and induction fractional-hp. motors; lists features, models, technical data.—Holtzer-Cabot Inc., Boston 19, Mass.

R-624 "SOLDERLESS-TYPE WIRE TERMINALS." 8-page reprint from June 1949 Electrical Manufacturing by maker's project engineer, T. C. Freedom; contains charts, diagrams, pictures; discusses selection of terminals at lowest assembled cost.—Aircraft-Marine Products Inc., 1523 N. Fourth St., Harrisburg, Pa.

R-625 SOLDERLESS WIRING CATALOG. 24-page pocket catalog describes and illustrates several of maker's wire terminals.—Aircraft-Marine Products Inc., 1523 N. Fourth St., Harrisburg, Pa.

R-626 DYNAMOMETER TEST STAND. 2-page bulletin illustrates and describes maker's "Add-a-unit" dynamometer test stand; lists features, applications.—Electro Mechanical Devices Co., 49 Selden Ave., Detroit 1, Mich.

R-627 "CEC RECORDINGS." 6-page, Vol. 3, No. 2 issue of this house organ features article titled "Mass Spectrometer Analysis of Solvents and Derivatives Now Simple Routine"; also articles on maker's new mass spectrometry and galvanometer services. — Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena 4, Calif.

R-628 RADIATION COUNTER TUBES. 8-page bulletin describes and illustrates maker's latest models self-quenching radiation counter tubes for research and industry; lists features, specifications.—Amperex Electronic Corp., 25 Washington St., Brooklyn 1, N. Y.

R-629 "PHOTOELECTRIC METHODS IN CLINICAL BIOCHEMISTRY." 4-page prospectus of book by G. E. Delory, M.Sc., Ph.D., assistant professor of biochemistry, Univ. of Manitoba, lists contents; contains specimen page.—The Jarrell-Ash Co., 165 Newbury St., Boston, Mass.

R-630 INSTRUMENT CATALOG. 40-page Catalog 15 illustrates and describes and illustrates maker's thermometers, psychrometers, barometers, hydrometers; lists specifications; contains simplified price list.—H-B Instrument Co., 2633 Trenton Ave., Philadelphia 25, Pa.

R-631 "MODERN PRECISION." 8-page, Vol. 9, No. 2 issue of this house organ presents articles featuring maker's instruments in metals, process industries, ceramics, power, research, teaching, testing.—Leeds & Northrup Co., 4902 Stenton Ave., Philadelphia 44, Pa.

R-632 "THE C-D CAPACITOR." 16-page, Vol. 14, No. 8 issue of this house organ continues article titled "The How and Why of Vibrators"; contains "The Radio Trading Post," a free market-place for buyers, sellers, and swappers.—Cornell-Dubilier Electric Corp., Hamilton Blvd., South Plainfield, N. J.

R-633 CONTROL VALVES. 12-page bulletin describes and illustrates maker's "Domotor" control valves; explains positioning operation of "Domotor"; lists features, specifications.—The Annin Co., 3234 Mines Ave., Los Angeles, Calif.

R-634 TURNS-INDICATOR. 2-page Bulletin 114 illustrates and describes maker's "Beckman Model W Duodial" turns-indicator for multi-turn devices; lists features specifications.—The Helipot Corp., South Pasadena Calif.

R-635 "TRACERLOG." 12-page No. 21 issue of this house organ features articles titled "A Discussion of Decade Scaling Circuits"; discusses uses of maker's instruments.—Tracerlab Inc., 130 High St., Boston 10, Mass.

R-636 "S. L. INSTRUMENT NOTES." 4-page No. 10 issue of this house organ presents articles titled "Frequency Calibration of Systems for Direct Registration of Vascular Pressures" and "Dynamic Pressure Transmitter Calibrator."—Statham Laboratories, Inc., 9328 Santa Monica Blvd., Beverly Hills, Calif.

R-637 LABORATORY RESISTOR. 2-page Bulletin 106 illustrates and describes maker's "Model T-10" voltage divider for laboratory and experimental uses; gives stock values, specifications; lists features.—The Helipot Co., South Pasadena, Calif.

R-638 MAGNETIC OXYGEN ANALYZERS. 4-page General Information Bulletin describes and illustrates maker's magnetic oxygen analyzers and recorders; gives principle of operation, characteristics, description of models.—Arnold O. Beckman, Inc., 11 W. State St., Pasadena 2, Calif.

R-639 VOLTAGE-DIVIDING RESISTORS. 4-page Bulletin 105 illustrates and describes maker's "Models F and G" precision linear voltage-dividing resistors; lists general and special features; gives stock values.—The Helipot Corp., South Pasadena, Calif.

R-640 "SCIENTIFIC APPARATUS AND METHODS." 34-page Summer 1949 edition of this house organ features articles titled "High Frequency Measurement of Electrolytes without Electrodes," "The Polarography of Cadmium," "Techniques for Cutting Glass Tubing"; Section two lists new, reinstated, discontinued items, specification changes.—E. H. Sargent and Co., 155-165 E. Superior St., Chicago 11, Ill.

R-641 "PRECISIONOMICS." 4-page, Vol. 1, No. 1 issue of this house organ features articles on uses of maker's instruments (Dual Recordomatic Titrometer, Dubnoff Metabolic Shaking Incubator, and others).—Precision Scientific Co., 3737 W. Cortland St., Chicago, 47, Ill.

R-642 WATER TEST AND CONTROL EQUIPMENT. 16-page booklet describes and illustrates maker's apparatus for water analyses; lists features, dimensions, applications.—W. H. & L. D. Betz, Gillingham & Worth Sts., Philadelphia 24, Pa.

R-643 LABORATORY FURNITURE. 4-page bulletin illustrates and describes maker's ready-made unitized laboratory furniture; gives dimensions, special features.—Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.

R-644 "THE C-D CAPACITOR." 16-page, Vol. 14, No. 9 issue of this house organ features article titled "Power Factor Correction"; contains regular "The Radio Trading Post" section.—Cornell-Dubilier Electric Corp., Hamilton Blvd., South Plainfield, N. J.

R-645 PAINT AND VARNISH DRYNESS TESTER. 4-page bulletin describes and illustrates maker's dust-free tester for determining the drying time of paints and varnishes; gives design, operation, test data.—Henry A. Gardner Laboratory, Inc., 4723 Elm St., Bethesda 14, Md.

R-646 WELDING CONTROLLERS. 32-page group of bulletins in a file-size folder describes and illustrates maker's welding controller combinations; induction heating; motor controls;

gives special features, applications.—Weltronic Co., 19500 W. Eight Mile Rd., Detroit 19, Mich.

R-647 AUTOMATIC PAINT FILM APPLICATOR. 4-page bulletin illustrates and describes maker's automatic blade applicator for laying down uniform films; gives specifications; performance examples.—Henry A. Gardner Laboratory, Inc., 4723 Elm St., Bethesda 14, Md.

R-648 ELECTRICAL TESTING AND CONTROL EQUIPMENT. 48-page booklet illustrates and discusses maker's plant, products, and personnel; contains 16 large pictures of various equipments.—Electro Mechanical Devices Co., 49 Selden Ave., Detroit 1, Mich.

R-649 VISCOSITY-TEST CUP. 6-page bulletin describes and illustrates maker's "No. 4 Ford Type" aluminum viscosity cup for determining viscosity of paints, varnishes, oils, etc.; discusses operation, care, temperature control, etc.—Henry A. Gardner Laboratory, Inc., 4723 Elm St., Bethesda 14, Md.

R-650 RADIO INTERFERENCE AND FIELD INTENSITY METERS. Two 4-page bulletins describe and illustrate maker's "NM-10A" and "NM-20A" radio interference and field intensity meters; "NM-10A" bulletin describes use of device on very low frequencies; "NM-20A" bulletin discusses portable unit for field engineer; both list performance specifications, unusual features.—Stoddart Aircraft Radio Co., 6644 Santa Monica Blvd., Hollywood 38, Calif.

R-651 RECORDING MILLIAMMETERS. 4-page Bulletin 949, "The Graphic," presents article titled "Atoms, Stars and Traffic Cops" describing some new accomplishments of recording milliammeters.—The Esterline-Angus Co., P.O. Box 596, Indianapolis 6, Ind.

R-652 VALVE CONTROLLER. 8-page Bulletin 3500 illustrates and describes maker's "Positrol" valve controller; discusses construction, principle of operation, characteristics, performance.—Fisher Governor Co., Marshalltown, Iowa.

R-653 CATHODE-RAY OSCILLOGRAPHS. 12-page bulletin describes and illustrates maker's "Types 304 and 304H" cathode-ray oscillographs; discusses circuits and power supplies, physical layout, applications, specifications.—Instrument Div., Allen B. DuMont Laboratories, Inc., 1000 Maine Ave., Clifton, N. J.

R-654 MOTOR CONTROLLER. 4-page bulletin illustrates and describes maker's electric motor speed controller; lists specifications, applications.—Servo-Tek Products Co., Inc., 4 Godwin Ave., Paterson 1, N. J.

R-655 "THE GENERAL RADIO EXPERIMENTER." 8-page, Vol. XXIV, No. 4 issue of this house organ features article titled "General-purpose A-M Standard-signal Generator"; lists specifications.—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

R-656 WIND INSTRUMENTS. 8-page Bulletin No. 6000 illustrates and describes maker's anemometers, wind direction instruments, wind recorders, pilot balloon theodolites; lists specifications.—W. & L. E. Gurley, Troy, N. Y.

R-657 SOLDER PREFORMS. 2-page bulletin illustrates and describes maker's solder pre-

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